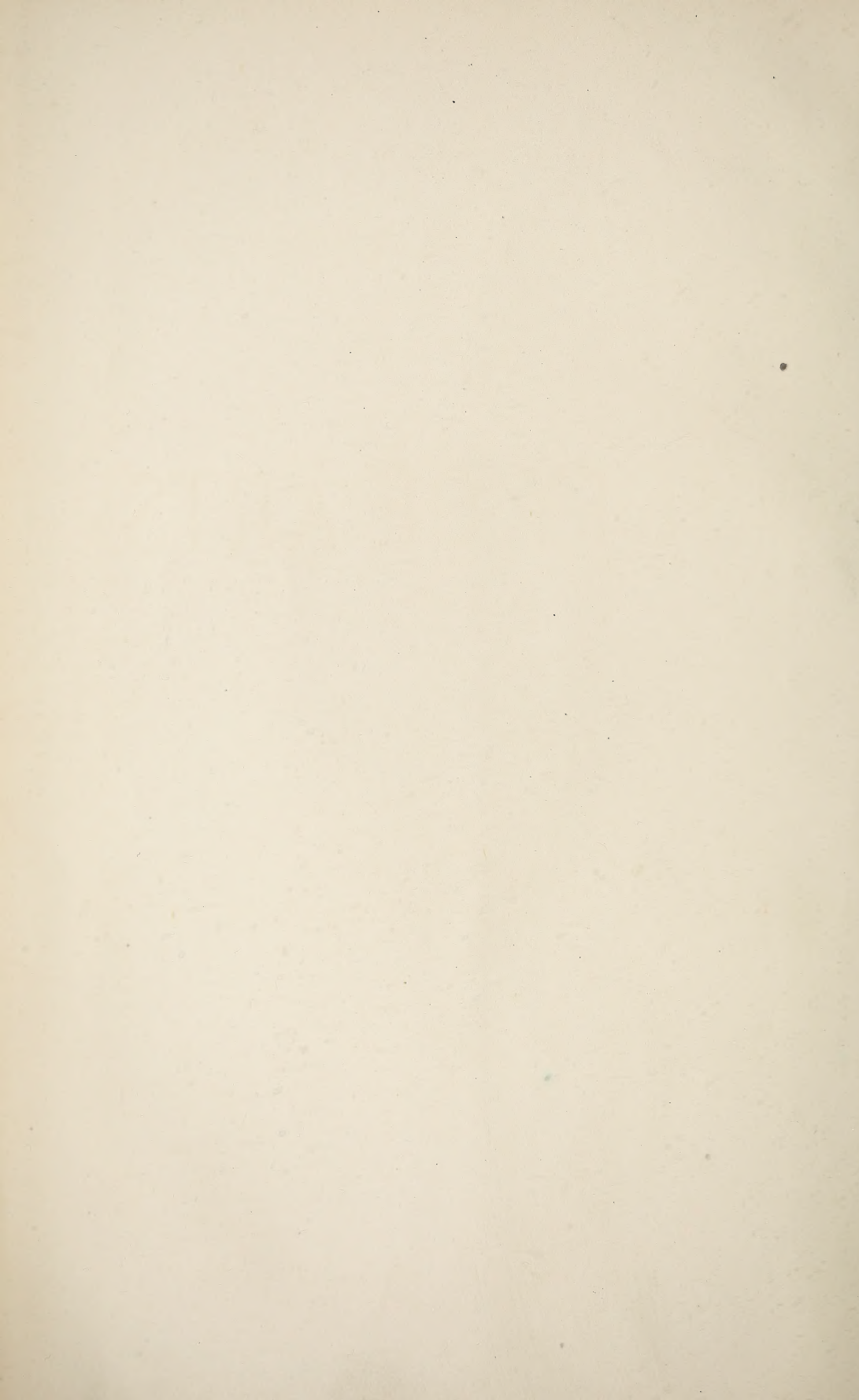






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FRIDAY, NOVEMBER 19, 1907.

[Vol. XLVII.]

ONE-HUNDRED-AND-FORTY-FOURTH SESSION, 1907-8.

COUNCIL.

H.R.H. THE PRINCE OF WALES, K.G., *President of the Society.*

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ACCOUNTANT.

HOWARD H. ROOM.

AUDITOR.

J. O. CHARTER AND CO.

SESSIONAL ARRANGEMENTS.

The Opening Meeting of the One-Hundred-and-Forty-fourth Session was held on Wednesday evening, the 17th of November, when an Address on "The Colonies: their Arts, Manufactures, and Commerce," was delivered by MAJOR-GENERAL SIR OWEN TUDOR BURNE, G.C.I.E., K.C.S.I., Chairman of the Council.

The following arrangements have been made for the four meetings before Christmas:—

Wednesday Evenings, at Eight o'clock.

NOVEMBER 24.—PROF. JAMES DOUGLAS, "Progress of Metallurgy and Metal Mining in America during the last Half Century."

DECEMBER 1.—PROF. LEONARD WALDO, D.Sc., "The American Bicycle—the Theory and Practice of its Making." SIR OWEN TUDOR BURNE, G.C.I.E., will preside.

" 8.—BENNETT H. BROUGH, "The Stockholm Exhibition of 1897." RT. HON. SIR BRIDGES SAMUELSON, Bart., F.R.S., will preside.

" 15.—SAMUEL RIDEAL, D.Sc., "The Purification of Sewage by Filtration." SIR DOUGLAS GALTON, K.C.B., F.R.S., will preside.

Papers for meetings after Christmas:—

J. F. ISELIN, "The Protection of Industrial Property."

ERIC H. S. BRUCE, M.A., "The Projection of Luminous Objects in Space."

CAPTAIN B. BADEN-POWELL, "Aeronautics."

EDWIN O. SACHS, "Stage Mechanism."

CLAYTON BEADLE, "The Recent History of Papermaking."

C. R. VALENTINE, "The Preparation of Meat Extracts."

R. BRUDENELL CARTER, F.R.C.S., "Children's Sight."

THOMAS POTTER, "Fireproof Construction."

A. D. PROVAND, M.P., "Compensation to Workmen."

Dr. CARL LINDE, "The Production of Low Temperatures."

JULES FUERST, "The Cinematograph."

T. R. TUFNELL, Chairman of the Royal Mail Steam Packet Company, "The Present Condition of the Sugar Industry."

INDIAN SECTION.

The meetings of this Section will take place on the following Thursday Afternoons or Evenings, at 4.30 or 8 o'clock:—

January 20, February 17, March 10, 31, April 28, May 19.

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesday Afternoons, at 4.30 o'clock:—

January 18, February 15, March 15, April 5.

APPLIED ART SECTION.

The meetings of this Section will take place on the following Tuesday Evenings, at Eight o'clock:—

January 25, February 22, March 8, 29, April 26, May 17.

CANTOR LECTURES.

Monday Evenings, at 8 o'clock:—

EUGENE F. A. OBACH, Ph.D., F.C.S., "Gutta Percha." Three Lectures.

LECTURE I.—NOVEMBER 29.—*The Raw Material*.—The year 1847—Early history and the Society of Arts—General properties and distinction from Caoutchouc—Botanical derivation and geographical distribution—Expeditions in search of gutta trees and experimental cultivation—Analysis of particular specimens and of various commercial brands—Exports from Singapore, imports into the United Kingdom and fluctuation of prices.

LECTURE II.—DECEMBER 6.—*The Cleaning Processes*.—Mechanical cleaning process—Loss during mechanical cleaning—Chemical washing process—Chemical hardening process—Extraction from raw material and from leaves by means of solvents—Advantages and disadvantages of the different processes—Natural substitutes for gutta percha.

LECTURE III.—DECEMBER 13.—*The Clean Material*.—Chemical composition, mechanical and electrical properties—Application for various technical purposes—Use of hardened gutta percha for golf balls—Absorption of oxygen and behaviour towards ozone—Deterioration and preservation—Artificial substitutes for gutta percha—Concluding remarks.

CYRIL DAVENPORT, "Decorative Bookbinding." Three Lectures.

LECTURE I.—JANUARY 24.—The beginnings of bookbinding—Assyrian clay tablets in their cases—Egyptian papyrus rolls—Vellum rolls—Roman diptychs—Medieval bindings in carved ivory, and metal covers with gems and enamels—Decorative bindings in Europe and the East up to and including the 15th century.

LECTURE II.—JANUARY 31.—Decorative bookbinding in Continental Europe, chiefly Italy, France, and Germany, from the 16th to the 18th centuries inclusive, with some notice of Oriental bindings.

LECTURE III.—FEBRUARY 7.—Decorative bookbinding in England from the 16th to the 18th century—Gold and enamelled bindings made for Henry VIII. and Queen Elizabeth—Bindings embroidered on velvet of the Tudor period, and on satin during the 17th century—Gold tooled work by Thomas Berthelet in the 16th century, by Samuel Mearme in the 17th century, and by Roger Payne in the 18th century, and the influence of these great binders upon the art.

HUGH STANNUS, "The Principles of Design in Form." Four Lectures.

February 14, 21, 28, March 7.

PROF. W. NOEL HARTLEY, F.R.S., "The Thermo-Chemistry of the Bessemer Process." Three Lectures.

March 14, 21, 28.

DR. D. MORRIS, C.M.G., "India Rubber." Two Lectures.

April 18, 25.

PROF. CARUS WILSON, "Electric Traction." Four Lectures.

May 2, 9, 16, 23.

JUVENILE LECTURES.

Two lectures, available for a Juvenile audience, will be delivered on Wednesday Evenings, January 5 and 12, at Seven o'clock, by WILLIAM RAMSAY, Ph.D., F.R.S., on "Fire."

CONVERSAZIONE.

The Annual Conversazione of the Society is fixed for Wednesday, June 22. Each member receives a card for himself, and one for a lady.

PROCEEDINGS OF THE SOCIETY.

CHARTER.—THE SOCIETY OF ARTS was founded in 1754, and incorporated by Royal Charter in 1847, for "The Encouragement of the Arts, Manufactures, and Commerce of the Country, by bestowing rewards for such productions, inventions, or improvements as tend to the employment of the poor, to the increase of trade, and to the riches and honour of the kingdom; and for meritorious works in the various departments of the Fine Arts; for Discoveries, Inventions, and Improvements in Agriculture, Chemistry, Mechanics, Manufactures, and other useful Arts; for the application of such natural and artificial products, whether of Home, Colonial, or Foreign growth and manufacture, as may appear likely to afford fresh objects of industry, and to increase the trade of the realm by extending the sphere of British commerce; and generally to assist in the advancement, development, and practical application of every department of science in connection with the Arts, Manufactures, and Commerce of this country."

THE SESSION.—The Session commences in November, and ends in June. The number of Meetings held during the Session amounts to between 70 and 80.

ORDINARY MEETINGS.—At the Wednesday Evening Meetings during the Session, papers on subjects relating to inventions, improvements, discoveries, and other matters connected with the Arts, Manufactures, and Commerce of the country are read and discussed.

INDIAN SECTION.—This Section was established in 1863, for the discussion of subjects connected with our Indian Empire. Six or more Meetings are held during the Session, three of which during the Session 1897-8 will be at the Imperial Institute.

FOREIGN AND COLONIAL SECTION.—This Section was formed in 1874 under the title of the African Section, for the discussion of subjects connected with the Continent of Africa. It was enlarged in 1879, so as to include the consideration of subjects connected with our Colonies and Dependencies, and with Foreign Countries. Four Meetings will be held during the Session.

APPLIED ART SECTION.—This Section was formed in 1886, for the discussion of subjects connected with the industrial applications of the Fine Arts. Six or more Meetings are held during the Session.

CANTOR LECTURES.—These Lectures originated in 1863, with a bequest by the late Dr. Cantor. There are several Courses every Session, and each course consists generally of two or more Lectures.

ADDITIONAL LECTURES.—Special Courses of Lectures are occasionally given.

JUVENILE LECTURES.—A Short Course of Lectures, suited for a Juvenile audience, is delivered to the Children of Members during the Christmas Holidays.

ADMISSION TO MEETINGS.—Members have the right of attending the above Meetings and Lectures. They require no tickets, but are admitted on signing their names. Every Member can admit *two* friends to the Ordinary and Sectional Meetings, and *one* friend to the Cantor and other Lectures. Books of tickets for the purpose are supplied to the Members, but admission can be obtained on the personal introduction of a Member. For the Juvenile Lectures special tickets are issued.

JOURNAL OF THE SOCIETY OF ARTS.—The *Journal*, which is sent free to Members, is published weekly, and contains full Reports of all the Society's Proceedings, as well as a variety of information connected with Arts, Manufactures, and Commerce.

EXAMINATIONS.—Examinations, founded in 1853, are held annually by the Society, through the agency of Local Committees, at various centres in the country. They are open to any person. The subjects include the principal divisions of a Commercial Education, Domestic Economy, and Music. A Programme, containing detailed information about the Examinations, can be had on application to the Secretary.

LIBRARY AND READING-ROOM.—The Library and Reading-room are open to Members, who are also entitled to borrow books.

CONVERSAZIONI are held, to which Members are invited, each Member receiving a card for himself and a lady.

MEMBERSHIP.

The Society numbers at present between three and four thousand Members. The Annual Subscription is Two Guineas, payable in advance, and dates from the quarter-day preceding election; or a Life Subscription of Twenty Guineas may be paid.

Every Member whose subscription is not in arrear is entitled :—

To be present at the Evening Meetings of the Society, and to introduce two visitors at such meetings, subject to such special arrangements as the Council may deem necessary to be made from time to time.

To be present and vote at all General Meetings of the Society.

To be present at the Cantor and other Lectures, and to introduce one visitor.

To have personal free admission to all Exhibitions held by the Society at its house in the Adelphi.

To be present at all the Society's *Conversazioni*.

To receive a copy of the weekly *Journal* published by the Society.

To the use of the Library and Reading-room.

Candidates for Membership are proposed by Three Members, one of whom, at least, must sign on personal knowledge; or are nominated by the Council.

All subscriptions should be paid to the Secretary, Sir Henry Trueman Wood, and all Cheques or Post-office Orders should be crossed "Coutts and Company," and forwarded to him at the Society's House, John-street, Adelphi, London, W.C.

CALENDAR FOR THE SESSION.

The following is the Calendar for the Session 1897-98. It is issued subject to any necessary alterations:—

NOVEMBER, 1897.			DECEMBER, 1897.			JANUARY, 1898.			FEBRUARY, 1898.		
1	M		1	W	Ordinary Meeting	1	S		1	Tu	
2	Tu		2	Th		2	S		2	W	Ordinary Meeting
3	W		3	F		3	M		3	Th	
4	Th		4	S		4	Tu		4	F	
5	F		5	S	Cantor Lecture I. 2	5	W	Juvenile Lecture I.	5	S	
6	S		6	Tu		6	Th		6	M	Cantor Lecture II. 3
7	M		7	W	Ordinary Meeting	7	S		7	Tu	
8	Tu		8	Th		8	S		8	W	Ordinary Meeting
9	W		9	F		9	M		9	Th	
10	Th		10	S		10	Tu		10	F	
11	F		11	S		11	W	Juvenile Lecture II.	11	S	
12	S		12	M	Cantor Lecture I. 3	12	Th		12	Tu	
13	M		13	Tu		13	F		13	M	Cantor Lecture III. 1
14	Tu		14	W	Ordinary Meeting	14	S		14	Tu	For. & Col. Section
15	W		15	Th		15	S		15	W	Ordinary Meeting
16	Th	Ordinary Meeting (Opening Meeting of the Session).	16	F		16	M		16	Th	Indian Section
17	F		17	S		17	Tu	For. & Col. Section	17	F	
18	S		18	M		18	W	Ordinary Meeting	18	S	
19	M		19	Tu		19	Th	Indian Section	19	M	Cantor Lecture III. 2
20	Tu		20	W		20	F		20	Tu	Applied Art Section
21	W		21	Th		21	S		21	W	Ordinary Meeting
22	Th	Ordinary Meeting	22	F		22	M	Cantor Lecture II. 1	22	Th	
23	F		23	S	CHRISTMAS DAY	23	Tu	Applied Art Section	23	F	
24	S		24	M	Bank Holiday	24	W	Ordinary Meeting	24	S	
25	M		25	Tu		25	Th		25	M	Cantor Lecture III. 3
26	Tu		26	W		26	S		26	Tu	
27	W		27	Th		27	M	Cantor Lecture II. 2	27	W	
28	Th		28	F		28	Tu		28	Th	
29	F		29	S		29	W				
30	S		30	M		30	Th				
31	M		31	Tu		31	F				

MARCH, 1898.			APRIL, 1898.			MAY, 1898.			JUNE, 1898.		
1	Tu	Ordinary Meeting	1	F		1	S	Cantor Lecture VI. 1	1	W	
2	W		2	S		2	M		2	Th	
3	Th		3	S		3	Tu	Ordinary Meeting	3	F	
4	F		4	M	For. & Col. Section	4	W		4	S	
5	S		5	Tu		5	Th		5	S	
6	M	Cantor Lecture III. 4	6	W		6	F		6	M	
7	Tu	Applied Art Section	7	Th		7	S		7	Tu	
8	W	Ordinary Meeting	8	F	GOOD FRIDAY	8	S		8	W	
9	Th	Indian Section	9	S		9	M	Cantor Lecture VI. 2	9	Th	
10	F		10	Tu	EASTER SUNDAY	10	Tu		10	F	
11	S		11	W	Bank Holiday	11	W	Ordinary Meeting	11	S	
12	M		12	Th		12	Th		12	S	
13	Tu		13	F		13	F		13	M	
14	W	Cantor Lecture IV. 1	14	S		14	S		14	Tu	
15	Th	For. & Col. Section	15	Tu		15	M	Cantor Lecture VI. 3	15	W	
16	F	Ordinary Meeting	16	W		16	Tu	Applied Art Section	16	Th	
17	S		17	Th		17	W	Ordinary Meeting	17	F	
18	M		18	F	Cantor Lecture V. 1	18	Th	Indian Section	18	S	
19	Tu		19	S		19	M		19	M	
20	W		20	Tu	Ordinary Meeting	20	Tu		20	Tu	
21	Th		21	W		21	W		21	W	
22	F	Cantor Lecture IV. 2	22	Th		22	Th		22	F	Conversazione
23	S	Ordinary Meeting	23	F		23	M	Cantor Lecture VI. 4	23	Th	
24	Th		24	S		24	Tu		24	F	
25	F		25	M	Cantor Lecture V. 2	25	W	Ordinary Meeting	25	S	
26	S		26	Tu	Applied Art Section	26	Th		26	M	
27	M		27	W	Ordinary Meeting	27	F		27	Tu	
28	Tu	Cantor Lecture IV. 3	28	Th	Indian Section	28	S		28	W	
29	W	Applied Art Section	29	F		29	S	WHIT SUNDAY	29	Th	Annual General Meeting
30	Th	Ordinary Meeting	30	S		30	M	Bank Holiday	30	F	
31	F	Indian Section	31	Tu		31	Tu				

The Chair will be taken at Eight o'clock at each of the Ordinary Meetings, the Cantor Lectures, and the Meetings of the Applied Art Section.

The Meetings of the Indian Section will commence at either Half-past Four or Eight o'clock, as may be announced from time to time.

The Meetings of the Foreign and Colonial Section will commence at Half-past Four o'clock.

The Annual General Meeting will be held at Four o'clock.

The Juvenile Lectures will be given at Seven o'clock.

Proceedings of the Society.

FIRST ORDINARY MEETING.

Wednesday, November 17, 1897; Major-Gen. SIR OWEN TUDOR BURNE, G.C.I.E., K.C.S.I., Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Allen, Herbert J., care of Messrs. Mowlem and Co., City and South London Railway, 7, Denman-street, London Bridge, S.E.
 Alton, James Poë, Elim, Grosvenor-road, Dublin.
 Ansell, Hubert, 75, Lombard-street, E.C.
 Baird, Sir Alexander, Bart., Urie, Stonehaven, N.B.
 Barr, John, Dinting, near Manchester.
 Barratt, James, care of Messrs. Baxter and Sadler, 14, Market-buildings, Flinders-lane, Melbourne, Victoria.
 Beach, Alfred Edward, Toddington, Winchcombe.
 Birdwood, Herbert Mills, C.S.I., 52, Stanhope-gardens, Queen's-gate, S.W.
 Boyd, Rev. Henry, D.D., Hertford College, Oxford.
 Braby, Newton, Bushy-lodge, Teddington.
 Bunting, W. Lightfoot, Quarry-hill, Accrington.
 Burton, William, The Hollies, Clifton-junction, near Manchester.
 Busk, Stephen, 30, Upper Brook-street, W.
 Carter, W. T., 10, Hare-street, Calcutta.
 Dale, Charles James, Denby, Haslemere-road, Crouch-hill, N.
 Dalton, Rowland Neale, Hillside, Lindfield-gardens, Hampstead, N.W.
 Darbshire, William Arthur, D.L., J.P., Penybryn, Carnarvon.
 Deas, Cairns, 7, Hastings-street, Calcutta.
 DeBavay, Aug., Foster Brewery, Collingwood, Melbourne, Victoria.
 Dickinson, William, Sunny-mount, Guildford.
 Diefenbach, J. von, Stuttgart, Wurtemberg.
 Durand, H. E. Sir Henry Mortimer, K.C.S.I., K.C.I.E., Tehran, Persia.
 Fanta, Ferdinand, 97, Queen Victoria-street, E.C.
 Ferguson, William Bates, M.A., 3, Plowden-buildings, Temple, E.C.
 Ferrand, Surgeon Lieut.-Colonel Edward, M.D., Bherampore, Madras.
 Field, William, M.P., Blackrock, Co. Dublin.
 Fields-Clarke, George Thomas, Southill-park, Biggles-wade.
 Finney, S., E.B.S. Railway, Sealat, Calcutta.
 Fitch, Frederick George, Pines, Enfield.
 Ford, Robert Thomas, Sunbeams, Windermere.
 Francis, Harry, Waterworks offices, Devonport.
 Franklin, L., 19, Gower-street, W.C.
 Garnett, Professor William, Technical Education Board, London County Council, St. Martin's-place, W.C.

Gaster, Léon, 37, Maida-vale, W.
 Gill, Francis N. G., care of Messrs. Binney and Co., Madras.
 Gout, George, Beilby-house, Cleethorpes, Lincolnshire.
 Hacking, William Henry, The Grange, Clayton-le-Moors, near Accrington.
 Halliwell, Edward, Alexandra-crescent, Dewshury.
 Hanks, Louis, 39, Berners-street, W., and 18, Denmark-road, Ealing Dean, W.
 Harral, Horace, Harris's Hotel, Queen-square, Bath, and Union Bank, Chancery-lane, W.C.
 Harris, Frederick William, 81, Gracechurch-street, E.C.
 Harvey, Francis G., care of Messrs. A. W. Perot and Co., Georgetown, British Guiana.
 Hodgson, Hon. H. Perceval, Kullakamby, Nilgiris, Madras Presidency.
 Hodson, William, 7, Finsbury-square, E.C., and Ecclesfield, Seven Sisters'-road, N.
 Holliday, Thomas, Lunnclough-hall, Huddersfield.
 Hoy, Peter, 7, Park-place, Clarence-gate, N.W.
 Hughes, W., Chepâk, Madras.
 Ingram, Frederick William, 237, Walworth-road, S.E.
 Johnston, Alexander R., 370, North Woodside-road, Glasgow.
 Lacey, Joseph Melville, Berampur, Ganjam, Madras.
 Latham, William, M.A., Q.C., 11, New-square, Lincoln's-inn, W.C., and 36A, Rosary-gardens, S.W.
 Law, James, Lieut. R.E., Stanley-house, Farnborough, Hants.
 Lawson, Robert, 133, Stephen's Green, Dublin.
 Lethbridge, Alfred Ernest, Russell-buildings, Frankfort-street, Plymouth.
 Lumb, Tom Gallon, Newton-hall, Poulton-le-Fylde.
 Lundholm, Carl Olof, Stevenston, Ayrshire, N.B.
 Lyell, David, West-park, Chesterfield, Derbyshire.
 Mabey, Frederick Oscar, 196, Amhurst-road, Hackney, N.
 Martyn, Thomas Graham, 11, Stratton-terrace, Truro, Cornwall.
 Mayson, C. M., 7, Scotch-street, Whitehaven.
 Müller, Henry A. C., Keughtung, S. Shan States.
 Neal, Robert Henry Bennett, Central Exchange, Plymouth.
 O'Dwyer, Michael Francis, I.C.S., Alwor, Rajputana, India.
 Oliver, Professor Thomas, M.D., 7, Ellison-place, Newcastle-on-Tyne.
 Paget, Clarence George, Guildford-house, London-road, Croydon.
 Pearce, James Edward, Craufurd, Maidenhead.
 Peck, Herbert Edgar, 65, South Molton-street, W.
 Phillips, John Henry Shawe, 33, Bridge-avenue, Hammersmith, W.
 Pilley, Thomas William, 33, Grove-hill-road, Denmark-hill, S.E.
 Purvis, Peregrine, The Cedars, Winchmore-hill, N.
 Robinson, J. Clifton, Pasadena, 345, Goldhawk-road, Shepherd's-bush, W.
 Scott, Harry, 3, Brixton-hill, S.W.

Sherwin, H. H., Waddesdon, Aylesbury.
 Shurmur, William, 4, Prospect-hill, Walthamstow, Essex.
 Simpson, E. Graham, 99, St. Martin's-lane, W.C.
 Smith, George Williams, 29, St. George's-road, Eccleston-square, S.W.
 Sperati, Guiseppe E., Rosa Alba-house, Highbury-park, N.
 Stevens, Benjamin Franklin, 4, Trafalgar-square, W.C.
 Stewart, Jeffrey, 35, Argyle-road, Ilford, Essex.
 Sykes, Joseph Charles, 15, Vernon-road, Clapham, S.W.
 Sykes, Captain P. Molesworth, Elcombs, Lyndhurst, Hants.
 Tate, Henry, Park-hill, Streatham-common, S.W.
 Thomason, William, junr., 162, Elms-road, Clapham-park, S.W.
 Tremearne, Shirley, 8, Old Court-house-street, Calcutta.
 Triana, Santiago Perez, 96 and 98, Leadenhall-street, E.C.
 Vaughan, J., 16, Manville-road, Tooting, S.W.
 Vérel, William Aristides, Fairholm, Larkhall, N.B.
 Wade, James L., 28, West Kensington-gardens, W.
 Watson, William Hill, Hygeia, Windsor-road, Willesden-green, N.W.
 Westland, Sir James, K.C.S.I., Finance and Commerce Department, Simla, India.
 Whittome, D. Knights, The County Studio, Hereford.
 Whowell, F., Carr-bank, Tottington Bury, Lancashire.
 Wilkinson, C. E., 36, Blythe-road, West Kensington, W.
 Wyatt, Arthur W., Ivor, Goldhurst-terrace, Kilburn, N.W.

The CHAIRMAN delivered the following address:—

THE COLONIES: THEIR ARTS, MANUFACTURES, AND COMMERCE.

It was my privilege last year, as Chairman of your Council, to speak of "India, its Arts, Manufactures, and Commerce," and, encouraged by your kind reception of my address on that occasion, I propose this evening to touch on these subjects with special reference to the Colonies—regions which constitute one portion of our empire, as our great dependency of India forms the other—and which we are all proud to call Greater Britain! I must acknowledge at the outset, that the subject is a difficult one, not only because the history and progress of the colonies have been treated in so complete a manner during the past session, in papers read before this Society, by Sir Charles Dilke and others of acknowledged

experience and ability, but because it is as difficult to treat them as one homogeneous whole, as it is to deal with them separately; amounting as they do to upwards of forty distinct administrations, covering a space, in the aggregate, of 9,500,000 square miles, of which the population, however, is comparatively small, since it is estimated at only about 22,000,000 persons, of whom about half are of British, or European, nationality.

Looking back through the vista of many centuries, we may see that in ancient times the word "colony" was used as meaning the settlement of a body of people in a new and permanent abode; while subsequently, in later years, the word was used of an outlying territory possessed by the mother country. In the present day, however, the term comprehends both the one idea and the other. Of the early migrations which carried a Greek population first into Asia Minor and then into Italy and Sicily, we have no knowledge sufficiently accurate to explain the exact reason of them; but it is believed that the original cause for the foundation of these colonies sprang from internal commotions and a superabundant population. In short, at one period of Grecian history, contentions were so rife among that artistic, learned, but unstable race, that when one of the contending parties acquired ascendancy, the situation was made so disagreeable to the other that these preferred to emigrate to snowy climes or desert sands rather than remain to be insulted and ill-treated at home. And again at a later period, the Greek population became so superabundant that relief was demanded in the shape of a diminution of numbers and was made a ground for colonisation. Thus, in course of time, the Grecian colonies became States in all respect independent, owning no Government but what they established for themselves, although they still looked, we are told, to the mother country for protection and assistance, while holding themselves under a strong obligation to befriend and assist her in difficulties.

The Roman colonies arose, it is said, out of a peculiarity of the status of the people. The land in the Roman Empire was originally regarded as belonging to the State, and therefore so soon as the democratic power became predominant, the people claimed it as belonging to themselves. This claim turned the land by degrees into private property, with the inevitable result that it was soon engrossed by the rich and powerful to the exclusion of those who were in want of money. So soon,

therefore, as the mass of the people became reduced to abject poverty, and asserted their original claims to the land in a formidable manner, they were shipped off by the democratic monopolists of it, to distant parts of the empire. Their land was given to them free of cost, and they still lived under Roman law, and were forced to be content with a lot which gave them certain advantages in the shape of exemption from military service and otherwise. Should any of you be fond of historical research, you might find these and other ancient emigrations an interesting study, and full of lessons not altogether inapplicable to ourselves and the days in which we live.

The founding of our own British colonies does not seem to have sprung, primarily, from either of the causes which actuated the Greek and Roman movements, but to have arisen rather from that love of adventure and spirit of mastery which have always adorned our national character. It must be noted at the same time that at one period of our history we were tempted, during the gradual growth of our colonies (extending over a period of about 300 years), to use some of these outlying possessions for the deportation of the criminal portion of our population, an arrangement which cannot be said to have met with either financial or political success. Without, however, going into any unnecessary details as to this and other questions affecting our colonies, I venture to place before you a general sketch of their progress and status, and to speak to you of their arts, manufactures, and commerce. Taken altogether, our colonies comprise about nine and a half millions of square miles of land, with a population of over 22,000,000 souls* (exclusive of protectorates) out of a total empire under our Sovereign of eleven and a quarter millions of square miles, with a population in all of over 360,000,000 souls! Yes! the largest empire ever founded in this world.

* The colonial possessions and protectorates of France (including Algeria) comprise a total area of about 2,500,000 square miles, of which 1,232,400 are in Africa, with a population estimated at about 20,000,000 souls. The French colonies cost France about £1,000,000 sterling, in addition to large grants from the Marine Budget and that of the Ministry of War, the exact extent of which are not, so far as I am aware, known. Our English colonies are said to cost us about £2,000,000 sterling annually, mainly for military and naval purposes, which is a moderate expenditure compared with the value of trade (over £50,000,000 sterling) between them and the mother country. As to Germany, the area of her colonial possessions amounts to about 1,000,000 square miles, with a population said to reach 10,000,000 souls. Of these possessions, 921,000 square miles are in Africa. At a time

since the flood; inasmuch as the great Roman Empire, of which historians think so much, comprised territories and populations which would now go into a very small corner of the British dominions. When we consider the bald facts thus curtly stated, it seems as difficult for any of us to remain a little Englisher as it is impossible not to be grateful that, amid the many felicitous circumstances of the Jubilee year in which we are living, the one which is likely to be longest remembered by the great mass of the English people is the loyalty, energy, and devotion to the Crown, manifested by their colonial fellow-countrymen, and the way in which they have been led to realize the fact that they belong to a great empire, carrying with it responsibilities, difficulties, and sacrifices of the highest order.

It is, perhaps, well known to you all that the greater part of our colonies has been acquired in comparatively recent times; although the first attempted colonial settlement, that of Sir Humphrey Gilbert in Newfoundland, was made as early as 1583. Briefly speaking, we possessed, three generations ago (about the time when our own Society was founded), Cape Colony, a part of the West Indies, and a large portion of North America; but so comparatively small were these possessions that they only represented a population of about 3,000,000 souls, and were managed in London by a small committee, answering in some measure to our present Board of Trade. During the reign of Queen Victoria, however, our Colonial Empire has been built up and consolidated by the occupation of large regions in all parts of the globe, until it has reached the dimensions just stated, and exists under the general control of the Colonial-office, which was established in its present form only about forty years ago.

It may interest you to be reminded that the colonies may be divided, for all practical purposes into two classes:—(1) the Crown Colonies, which are controlled by the Home

when Germany is contemplating a large increase to her navy for the purpose of protecting and extending the "greater Germany beyond the seas," it may be interesting to note (*Times*, 10th October, 1897) that her existing colonies, or rather protectorates, cost her about £400,000 a year, and that the value of the trade between these colonies and the mother country is about £570,000. To pay £400,000 for £570,000 worth of trade costs the German taxpayers 15s. in the £. The total German population throughout the German colonies amounts only to 1,803, of whom at least half are either soldiers or officials, and exceeds by only 25 the non-German white population, numbering 1,778. As the German Colonial Society now amounts to 19,500, every German colonist has nearly 11 self-constituted champions of his cause at home.

Government, and (2) those possessing responsible Governments, in a greater or less degree, in which the Crown exercises no special control, except in the appointment of the Governor and in a veto on legislation. In the first category may be included Antigua, Bahamas, Barbadoes, Basutoland, Bermudas, British Guiana, British Honduras, Ceylon, Dominica, Falkland Islands, Fiji, Gambia, Gibraltar, Gold Coast, Grenada, Hong Kong, Jamaica, Lagos, Leeward Islands, Malta, Mauritius, Montserrat, St. Helena, St. Kitts and Nevis, St. Lucia, St. Vincent, Seychelles Islands, Sierra Leone, Straits Settlements, consisting of Singapore, Penang, Malacca, and certain Malay States; Tobago, Trinidad, Turks Islands, Virgin Islands, and Zululand; also some protectorates which will be presently mentioned. In the second category may be named Canada, Newfoundland, Australasia (including British New Guinea), the Cape of Good Hope, and Natal. In addition to these two classes of colonies there are, as you know, certain British* possessions and protectorates which are at present controlled by High Commissioners or Chartered companies, or are in a position of dependency in other forms on the British Government. Firstly, may be mentioned the Bechuanaland Protectorate (twice as large as France in area), which has recently been incorporated in Cape Colony; then comes British Central Africa, containing the territory better known as Nyassaland; then British East Africa and Zanzibar; then Brunei (in Borneo), Cyprus, the Niger Coast Protectorate, the Niger territories, North Borneo, Rhodesia, Sarawak, the Western Pacific Islands, and Cook or Hervey Islands, and so on. And as all Europe seems intent on spiriting away Africa from its original owners, it may here be noted that the British possessions in that vast continent reach an area of about 3,000,000 square miles, or a territory nearly as large, in the aggregate, as Europe.

It is obvious that the initial want felt in these enormous tracts of land is an intelligent white population which can live in them. This is, no doubt, rapidly becoming one of the great problems of the day. At present only an average of 16,000 souls go annually from this country to Canada, 10,000 to Australia, and 24,000 to South Africa; whereas at least three

times this annual amount of emigration has to be reached if we are to attain that solidarity and strength in the colonies which we all so much desire. The want of the fairer portion of our population is a want particularly felt at the present moment in the colonies; in fact, there is a deficiency of women in proportion to men, which amounts in some cases to 50 per cent., although here at home it is all the other way, more especially in the Channel Islands which are therefore worthy of a visit from those of our colonial bachelors who may be contemplating a change in their sad and solitary condition!

To complete these somewhat perfunctory remarks as to the colonies, it only remains to say that, so far as one is able to express an opinion after an examination of official papers, their financial condition is, in most of them, sound, and is, in others, improving; that their provision for elementary, technical, and higher education is in some respects superior to that in the mother country; that in regard to modern communications, not to speak of roads and canals, there is a satisfactory progression, since they possess at present about 34,000* miles of railway and 120,000 miles of telegraph lines, constructed at a cost in all of about £350,000,000 sterling. I quote these figures merely to give you an idea of the gradual advance that is being made in these important means of communications, inasmuch as only twenty years ago there were in all the colonies but 7,000 miles of railway and 20,000 miles of telegraph lines. This fact is so far a useful one, inasmuch as progress in railways and other means of communication often indicates advance in population, wealth, and civilisation.

To defend our great colonial possessions is naturally a question of immense importance, and it is one that we have every reason to believe is engaging the earnest attention of our responsible authorities. Speaking of this matter generally, it may be noted that since the year 1870 Imperial troops have been gradually withdrawn from the self-governing colonies, so that, with the exception of the naval station of Halifax (Nova Scotia) and of Cape Town, their defence on land rests entirely on their local forces. Certain Crown and other colonies, however, such as Gibraltar, Malta, Natal, Mauritius, Sierra Leone, St. Helena, Ceylon, Straits Settlements, Hong Kong, Bar-

* Other than those controlled by India, such as Aden, Perim, Socotra, the Laccadive, Nicobar, and Andaman Islands; and also Ascension, the affairs of which are managed by the Admiralty. For all these and other interesting facts see the *Colonial List*, admirably edited by Mr. John Anderson, C.B.

* There are 22,000 miles of the one and 37,000 miles of the other in the United Kingdom, and 20,000 miles of the one and 44,000 miles of the other in India.

badoes, Jamaica, St. Lucia, and Bermuda, still possess British garrisons. The various local forces of the combined colonies, including militia, volunteers, and constabulary, amount to more than 100,000 men in all, the regular militia alone furnishing a fine force of upwards of 80,000 well-equipped troops. The maritime defence of our colonies still remains in the hands of the Imperial navy, which furnishes some 80 vessels in all for service in what may be called colonial waters. Canada and the Australian Colonies have taken considerable pains, however, to make additional provision in this respect; nor can we regard, without a full appreciation of its value, the recent proposal of Sir Gordon Sprigg, made on behalf of the Cape Government, to construct a first-class battleship at the expense of that colony. Strong fortifications have been erected at Cape Town, Freetown (Sierra Leone), St. Helena, Singapore, Hong Kong, and elsewhere, to which the Imperial Government has contributed half the cost. There are also Imperial naval stations at Simon's Bay (Cape Town), Trincomalee (Ceylon), Bermuda, Esquimalt (Vancouver's Island), Halifax, Malta, Gibraltar, St. Lucia, Hong Kong, Ascension, and other places. It is possible that ere long we may see a considerable improvement in the arrangements made for the naval and military defence of our colonies, as an outcome of the useful conferences of June and July last between our able Secretary of State, Mr. Chamberlain, and the Premiers of the self-governing colonies,—conferences so wisely brought about by Her Majesty's present Government.

Now, in all that I have ventured to say as to the condition of our Colonial Empire, I have intentionally given general facts and figures only, for to mention each colony and dependency separately would occupy many addresses and many evenings. But in order that you may gather a general idea of what is being done by some of our principal colonies (as a key to the progress of others which, although not named, are of no less comparative importance), I may mention that Canada, which in extent is, of itself, almost as large as Europe, has a system of canal, river, and lake navigation of over 2,700 miles in length; that she has an important network of railways 16,000 miles in extent, besides 32,000 miles of telegraph lines; and that she maintains a separate force of about 35,000 regular militia to preserve order in her long line of frontier besides a reserve force liable to be called out by general

conscription in moments of danger. At the same time her progress in education, agriculture, and industrial pursuits is most encouraging. The same may be said, in a greater or less degree, of other colonies. For instance, to take Australasia, it may be mentioned that in New South Wales, one of our oldest established settlements (and in area considerably larger than France), nearly 3,000 miles of railway have been built at a cost of £37,000,000, besides innumerable lengths of telegraphs, roads, and tramways. In Victoria we find an almost equal amount of progress. Queensland is not far behind. West Australia (which is more than four times as large as France, and is now rapidly developing unexpected sources of mineral wealth) is also waking up to her interests both in education and in means of communication. South Australia also holds her own in these respects. New Zealand, again (which, as you may know, consists of islands which extend 1,000 miles in length, with a considerable sea-board) is not only one of the most favoured of our colonies in scenery and climate, but is making good progress in education and other essentials, besides paying more attention than some of her sister colonies to her means of defence against foreign attack.

It would, indeed, be pleasing to review in detail the condition in these respects of other of our colonies if time permitted one to do so. It may be sufficient, however, to say here that each separate portion of our Colonial Empire, whether it be directly under the Crown, or whether it be self-governing, has its special value and its special characteristics, and we may rest assured that the events of this year have caused each of them to realise its own peculiar importance to the Empire at large; to grasp the necessity for its protection against foreign trade or foreign aggression; and to show to the world at large the value and weight of a loyal adhesion to the mother country, which, we may all believe, has no more devoted and warm-hearted sons and daughters than those who live, so to speak, in the hollow of her hand and in the tips of her fingers.

To pass on now to the main object of this address, the *Arts, Manufactures, and Commerce* of the colonies, I may remind you again, as I reminded you last year, that the term *Art* is defined by Lord Bacon as a proper disposal of the things of nature by human thought and experience, so as to answer the several purposes of mankind. Arts

are therefore commonly divided into useful and mechanical, fine and liberal, the former being those wherein the hand and body are more concerned than the mind, and are known by the name of trades; and the latter being those which depend more on the labour of the mind, and are the produce of imagination. In the colonies we find a very creditable admixture of both these attributes, although it may be sufficient on the present occasion to refer more particularly to the fine and liberal arts, in which the colonies are making a progress that is eminently satisfactory.

Dealing with Canada first, it seems that there are several art schools in operation in connection with the many valuable educational establishments of that colony. Canada offers a fine field for the talent of nature's true artists, and although Canadian art has hitherto been imitative rather than creative, yet of late years, as the recent Chicago Exposition has proved, Canadian artists can produce pictures which show an individuality of expression which is most creditable to them, among whom more notable names are those of O'Brien, Reid, Bell-Smith, Harris, Forster, Brymner, and Miss Bell. We are reminded also by a writer on this subject (Mr. Bourinot, C.M.G.) that the Marquis of Lorne and the Princess Louise, during their residence in Canada, did much to stimulate a wider taste for art by the establishment of a Canadian academy and the holding of annual exhibitions. We may feel sure, therefore, that in course of time Canada will give still greater attention to this branch of her progressive education than she does even now, and will soon follow the useful example of her Australian sisters in the establishment of her galleries and advanced schools of art.

In the seven great colonies of Australia we find much progress made in the direction of art. Half a century ago no one troubled himself at the Antipodes about art, whereas now it is slowly gaining for itself a position which tends towards a distinctive Australian school. In New South Wales, for example—the mother colony of the Australias—an academy of arts was founded some twenty-five years ago at Sydney, in connection with other branches of public education, and an art gallery was subsequently opened and designated a "National Gallery," which is aided from Government funds and is freely accessible to the public. The collection in this gallery represents a value amounting to about £90,000; while a Colonial Court, devoted to the work of Aus-

tralian artists, is becoming a feature in the collection, and the purchase of a picture by the State is considered by these artists to be a high distinction. There are also in the country districts of New South Wales many schools of art allied with technical and other educational establishments. As to Victoria, we find that to her belongs the honour of being the first to initiate an art movement in the Antipodes, for after founding a public library at Melbourne in 1853, she added to it, a few years afterwards, a national gallery, in which the collection now amounts to about 450 oil paintings, besides large numbers of water-colour drawings, engravings, and statuary and other works of art. Here it may be added, a system of intercolonial exchange of pictures was inaugurated in 1894 for temporary exhibition purposes. There are also in Victoria 18 provincial schools engaged in teaching science, art, and trade subjects. In South Australia there is an art gallery; while drawing is made a compulsory subject in the State schools. In Queensland there are many institutions which comprise schools of art; and in connection with such a school established at Brisbane, a technical college has been founded with much success.

In short, in our Australian colonies, and in New Zealand, there is a wide field for the genius of Antipodean artists who, although without such beautiful green fields and idyllic rural scenery as we possess in the United Kingdom, yet can appeal direct to nature of diverse character "from the frigid heights of the Australian Alps to the waving palms and jungle-fringed rivers of tropical North Queensland." And we need only mention men like Lister, Streeton, Mahony, McCubbin, Fullwood, Spence, Roberts, Pignett, Hanson, and others, to come to the conclusion that there is a creditable amount of home talent in Australia which can appeal to limitless plains, silent forests, dark lily-covered lagoons, and the wild free life of the bush, for a thousand inspirations towards its development. There are many illustrations in England of the genius of these painters, and no doubt some of you have seen excellent specimens of Australian and New Zealand art in the Imperial Institute and in the Royal Colonial Institute and elsewhere—specimens which will bear good comparison with productions nearer home.

Passing on to the Cape, it may be mentioned that, although the fine arts do not occupy, at present, a large space in its rapidly improving

educational establishments, yet that colony has recently passed an Act of Parliament for the purpose of establishing an art gallery at Cape Town, to contain, among other things, a collection of paintings and works of art hitherto held in trust by the South African Fine Arts Association. If I here confine these few remarks as to art to some of our larger self-governing colonies, it is merely, as I have before observed, for want of time. I have, perhaps, said enough to give you an impression that the subject is not neglected in our Colonial Empire, and I cannot better leave this portion of my address than by re-echoing the words of a true enthusiast (Frank Hutchinson) who tells us that the possibilities of art in Australia are, from a purely artistic point of view, limitless; for here are a thousand undiscovered charms and mysteries, sublime atmospheric effects, and infinite diversities of scenery and life as fresh as from the Creator's hand. With Australia, indeed, as with the minstrel of old, the way may be long and the wind may be cold, but she has at least within her the spirit of youth and daring, and ever ahead and beckoning her onward is—

Hope on the mountains
Beautiful as morn.

Coming now to *Manufactures and Commerce*, we understand the one term as meaning a commodity produced from raw or natural materials either by the work of the hand or by machinery, and the other as implying the exchange of articles of any kind for money and other commodities. Again, to take a few of our larger colonies as examples, we find that at the Cape are about 2,200 industrial establishments, such as flour mills, breweries, tanneries, and mines, employing 33,000 persons, and annually producing articles worth about £10,000,000 sterling. Although agriculture and fisheries form the staple industry of Canada, and the manufacturing element there is comparatively in its infancy, yet the factory establishments of sorts, including the manufacture of wood pulp, are making great progress, and employ about 250,000 persons in the making of a variety of goods, from buttons to steam-engines. Canada possesses unrivalled means for the development of her manufactures, on account of her abundant water supply, her timber, and the excellent external and internal facilities which she possesses, not only for the importation of raw materials, but for the distribution of the manufactured article. In New South Wales again there are nearly 2,500 manufactories of

kinds employing about 45,000 hands; in Victoria, 2,675 factories engage 42,000 persons; in South Australia, 750 factories give work to 10,000 hands; and in New Zealand, about 2,500 factories employ 30,000 men, and so on.

As to *Commerce*, it need only be mentioned here that the external trade of the colonies, as a whole, has increased from £34,000,000 sixty years ago to about £300,000,000 at the present time, and that colonial shipping, *i.e.*, shipping actually belonging to the Colonies, has risen from 450,000 to 1,500,000 tonnage, to convince you of the progress made by our Colonial Empire in this direction. Here, again, a few separate instances may be of interest to you. The annual commerce of the Cape, for instance, half a century ago, was worth £600,000; it is now worth £27,000,000, while the tonnage of shipping, inwards and outwards, of Cape Colony has risen from 150,000 to 3,500,000 tons. Again, while Canada has now become a great maritime country, her imports have risen within the same time from £4,000,000 to £24,000,000, and her exports from £2,500,000 to £24,000,000. New South Wales, we are reminded by Sir Charles Dilke, has for many years exported over £20,000,000 of produce every year, of which half is wool, and she imports from the United Kingdom alone about £6,000,000 worth of goods. Victoria, again, exports over £14,000,000 of produce, and from the United Kingdom alone imports £5,500,000 worth of goods. New Zealand, again, exports about £10,000,000 worth of produce, and from the United Kingdom imports about £4,500,000 worth of goods, and so on. It may be added that Ceylon, through the enterprise of its planters, is rapidly increasing her tea industry, her export of this commodity alone into the United Kingdom reaching upwards of £3,500,000 sterling. Her general trade has also much grown during the Queen's reign, her tonnage of British ships entered and cleared, exclusive of coasting trade, having increased from 10,000 tons to 5,452,547 tons. The same tale of graduated prosperity may be told of other sister colonies.

To speak generally, I may state, on the authority of official publications, that the trade of our colonies as a whole is, for the most part, an exchange of raw materials for manufactured goods, and that they import into the United Kingdom about £10,000,000 sterling worth more goods than they receive from us. The balance of trade appears, therefore, to be at present in their favour so far as the mother country is concerned. By far the largest item

is wool, coming from Australia and South Africa, with some from Canada and the Falkland Islands. Out of a total of about £30,000,000 of this particular export, nine-tenths come to the world's great wool mart in London, making up one-third of the total of England's colonial imports. Next to wool stand sugar and molasses, the product of the West Indies (with British Guiana and British Honduras), Mauritius, Fiji, Natal, Queensland, and the Straits Settlements. These commodities produce an export of about £7,000,000, and chiefly go to the United States. Almost as important as sugar is the export of hides, skins, leather, and furs from Australasia, South Africa, Canada, and Newfoundland, amounting to about £6,000,000 and mainly consigned to London. In the imports of dairy produce into the United Kingdom the colonies are beginning to figure largely. From New Zealand (which has taken the lead in the supply of frozen meat) we receive some 54,000 cwt. of butter; from Australia some 260,000 cwt., besides 93,000 cwt. of cheese; and from Canada 40,000 cwt., besides 1,200,000 cwt. of cheese.

Other items of export from the colonies are numerous, the chief being coal (New South Wales and Canada); fish, fish oils, and lobsters (Newfoundland, Canada, the Cape, and Barbadoes); copper (the Cape, New South Wales, South Australia, Canada, Newfoundland, and Queensland); tea (Ceylon); coffee (Ceylon, Jamaica, and Straits Settlements); fruit, (Trinidad, Jamaica, Tasmania, Fiji, Canada, and British Honduras); cocoa (Trinidad and Grenada); and horses (Canada and New South Wales). Smaller values are represented by ostrich feathers, palm oil and kernels, cinchona, logwood and plumbago, &c. Some commodities of prime importance are, we are told, as yet wanting in our colonies, for but little iron or quicksilver is produced in them, although both Canada and New South Wales work their own iron and steel to a small extent; and practically no petroleum, sulphur, or platinum exist. A large field of nickel has however been recently discovered in Ontario, and Canada now ranks as one of the largest sources of that metal.

To pass from these minor sources of wealth to the production of the more precious minerals, it may here be noted that the grand aggregate value of the gold production of the world from 1851 to 1896 inclusive (*Statist*) is estimated at about £1,163,100,000, or approximately in weight 300,000,000 ounces of gold. The total production of silver for the same period has

been, by weight, 3,282,600,000 ounces. The chief gold producers are:—

	£
United States.....	417,980,000
Victoria	243,841,000
New South Wales.....	43,400,000
New Zealand	52,392,000
Queensland	39,189,000
Tasmania	4,417,000
West Australia	4,100,000
South Australia	1,983,000
Transvaal	42,331,000
Indian Mines	5,911,000

Taking the year 1896 only, we learn that the production of the world's gold fields was in that year:—

	£
United States	10,800,000
Australasia	8,988,000
Transvaal	8,604,000
India	1,245,000
Russia and other countries....	10,697,000

or an average of about £40,000,000, against one of £21,738,000 fifteen years ago.*

Amid all this record of prosperity in the colonies generally (although Australia and others have not been free from difficulties and financial disasters) the West Indies alone appear to have been better off sixty years ago than now. Yet although individuals have suffered, and some of the islands have also suffered, taken by themselves, certain increases in population, revenue, and trade have taken place even here. The recent report of the West Indian Commission has placed at our disposal a vast array of facts in connection with these colonies, whose resources, in the majority of cases, depend mainly at present upon the maintenance of the sugar industry. This industry has suffered considerable depression during the past fifteen years by the manufacture of beet sugar on the continent of Europe,

* The whole gold product of the British Empire now reaches about £10,000,000 sterling annually, or nearly one-third of the world's production. This is contributed mainly by Australia and New Zealand, and India, but the Gold Coast, Canada, British Guiana, and the Cape are also gold producers. Of the other principal minerals, the Empire yields £3,500,000 sterling of silver; copper, £1,250,000; tin, £1,500,000; iron, £1,000,000; coal, £4,500,000; and precious stones and other miscellaneous minerals, £5,000,000. Including the United Kingdom the total mineral production of the Empire is valued at over £100,000,000 sterling. It has been estimated that the Empire also possesses one-fourth of the world's stock of cattle, one-twelfth of its stock of horses, and one-fourteenth of its stock of swine. The average colonial export of corn is over £5,000,000 sterling, while the export of oxen, sheep, and dead meat exceeds £4,000,000, nearly the whole from Australia and Canada. Canada furnishes us with over £3,000,000 sterling of timber annually, and the Cape from £3,500,000 to £4,000,000 worth of diamonds.

which has rapidly developed, under the continental system of giving bounties on exported sugar, and of protecting home manufactures by a heavy customs duty. Our West India industry is said to be almost threatened with extinction unless the Imperial Government sees its way to come to its aid in some shape or form; as to which, as is usual in this country, there are a multitude of advisers who recommend many different recipes.

The few facts that I have thus brought to your notice will show you, I venture to think, that the commerce of our great Colonial Empire holds a good position in the world, and that we all have reason to feel indebted to Her Majesty's Government, as represented by our present Secretary of State for the Colonies, for desiring to make closer and more intimate the commercial and other relations between this country and her great colonial possessions. A judicious commencement of this policy has already been initiated by the recent desire of Canada to grant preferential terms to the mother country, and by the consequent denunciation by our Government of certain inconvenient commercial treaties with Germany and Belgium; and we may hope, perhaps, that this may be followed by a Commission of Inquiry into the whole subject of our commercial relations, and by further assistance from our self-governing colonies, who may eventually be disposed to make a preferential arrangement with the mother country *alone*, as suggested at the recent Conferences, and refrain from granting such preference to any foreign country; inasmuch as in this latter case the arrangement would be controlled by the "most favoured nation" clause (inserted in many treaties between Her Majesty and other powers) and might therefore be useless to us, as necessitating the concession of similar terms to those countries.

The importance of this question may be gathered from a recent Blue-book, which has reference to the competition that now exists in the markets of the world between British and foreign commodities. While we need not be much alarmed at the information which has been given to us at the instance of the Colonial-office, yet we are reminded of certain unpalatable truths recently summarised by one of our evening journals (*St. James's Gazette*), which tells us that Germany is pretty well known as the chief *bête noir*; the United States is another; Belgium is a third; and in the East Japan is waking up all the drones. Germany is reported as displacing us with apparel and

slops in Sierra Leone, New South Wales, Victoria, and the Straits; gunpowder in Lagos; beer and ale in British Honduras, Trinidad, the Gold Coast, Sierra Leone, the Straits, and the Cape; cement in the eastern colonies and South Australia; chemical products in New South Wales; clocks and watches in the Straits and the Cape; cotton manufactures in the Bahamas, the Straits, Tasmania, Sierra Leone, Malta, and Hong Kong; furniture in Sierra Leone and Lagos; glassware in the Straits; hardware in the Windwards, Sierra Leone, Malta, Lagos, and the Straits; tools in the Gold Coast, Tasmania, and Trinidad; iron and steel in the Straits; nails in New South Wales and Hong Kong, wire in Victoria and West Australia, and yellow metal in Hong Kong; and finally with woollen manufactures in the Straits, Cyprus, and Tasmania. The United States, in their turn, are displacing us with gunpowder in South Australia (a rather violent ejection this!); with beer in Jamaica; cheap clocks and watches in the Leeward Islands and South Australia; cotton manufactures in British Honduras and the Windwards; furniture in the Cape Colony; lamp chimneys in Victoria; hardware in the Bahamas; implements and tools in Tasmania and Trinidad; and in the Cape with wire nails and plate and plated ware. Belgium, it adds, is beating us with firearms ("cheap and showy") in Ceylon, the Straits, Victoria, and South Australia; with candles in Hong Kong and New South Wales; glassware in the Straits, the Cape, New South Wales, and Victoria; iron and steel in the Straits, and nails in New South Wales and Hong Kong. France is a successful competitor against us with cashmere in the Windwards, haberdashery at Sierra Leone, and glassware at the Cape. Austria beats us with her lighter and cheaper furniture in the West India colonies, Ceylon and the Cape, and with finer woollen manufactures in Cyprus. It sounds sad to read that there are particular classes of goods in which the foreigner does more than 50 per cent. of a trade that a few years ago was admittedly British. Thus the United States now do more than one-half of the entire trade in carriages and waggons with the Cape; Germany more than half of the Straits trade in biscuits and bread; Germany in the last decade has acquired a moiety of the Hong Kong trade in yellow metal; the United States have gained 10 per cent. of Victoria's custom for hammers; the States and Germany supply 66 per cent. of the implements required

by Tasmania; and Germany supplies nearly all New Zealand's musical instruments.

And now I must close this Address, with many apologies for its omissions and defects. I cannot conclude, however, without expressing an earnest belief that the loyalty, the industry, and the level-headedness of our fellow countrymen in the Greater Britain of which we are so proud, will inspire all of us at home with a still greater appreciation than hitherto of the value to the mother country of her Colonial and Indian Empire; and that a broad and liberal spirit will in the future be infused into the deliberations of those who have been too prone in the past to degrade imperial questions to a mere party level. May I not add that we can, with advantage, look forward to the time when Mr. Chamberlain's dream may be fulfilled as to the formation of a great Council of the Empire, to which delegates from our colonies and dependencies may be appointed—a Council which shall have a real and effective voice in the relations between the mother country and her great colonial possessions, and help to bind them all together in an enduring bond of common interests, good fellowship, and material succour and support. In the words of Aristophanes, in the "Lysistrata," as translated by Mr. Bickley Rogers:—

"Also remember the cities, our Colonies,
Outlying States in the East and West;
Scattered about to a distance surrounding us,
These are our shreds and our fragments of wool:
There to one mighty political aggregate
Tenderly, carefully, gather and pull,
Twining them all in one thread of good fellowship;
Thence a magnificent bobbin to spin,
Weaving a garment of comfort and dignity,
Worthily wrapping a people therein."

Before delivering his Address the CHAIRMAN presented the Society's medals which have been awarded during the last Session.

For papers at the Ordinary Meetings:—

To BENNETT H. BROUGH, Assoc.R.S.M., for his paper on "Mining at Great Depths."

Mr. Brough, Secretary to the Iron and Steel Institute, and a distinguished expert on mining, is well known to the Society as the reader in former years of several valuable papers, and also as a Cantor lecturer on mine surveying.

To THE RIGHT HON. HORACE PLUNKETT, M.P., for his paper on "The Recommendations of the Recess Committee for the Development of Ireland's Industrial Resources."

Mr. Plunkett's labours on behalf of agriculture in Ireland are well known, and the Recess Committee, which owes its existence to him,

gives promise of rendering valuable assistance in this respect to that country.

To EVERARD R. CALTHROP, for his paper on "The Barsi 2 ft. 6 in. gauge Light Railway."

The Society is indebted to Mr. Calthrop for an interesting account of a remarkable engineering work in India, carried through mainly by his own determination and skill. This enterprise promises to solve economically some important questions relating to railway construction in that Empire.

To W. B. ESSON, M.Inst.C.E., for his paper on "The Transmission of Power by Alternating Electric Currents."

Mr. Esson has long been known for his devotion to the science of electricity, and in this paper he has given us valuable information on a subject of the greatest importance in the economy of electrical engineering.

To M. J. R. DUNSTAN, M.A., F.R.S.E., for his paper on "Dairy Produce and Milk Supply."

The importance of a sufficient dairy supply obtained from our own country is patent to all, and Mr. Dunstan's suggestions in furtherance of this national object are of great value.

To ROBERT H. JONES, for his paper on "Asbestos and Asbestic."

Of late years asbestos has come so largely into industrial use, that the discovery of an unlimited supply of a material called asbestic, with similar qualities, cannot fail to be of considerable value from a commercial point of view.

To PERCY F. FRANKLAND, Ph.D., F.R.S., for his paper on "London Water Supply."

In former years, Dr. Percy Frankland has read some valuable papers and delivered several courses of Cantor lectures before the Society. This paper, on a subject to which he has devoted so much attention, is of a reassuring character in respect to the condition of the London Water Supply.

In the Indian Section:—

To SIR CHARLES ALFRED ELLIOTT, K.C.S.I., for his paper on "Measures taken by Government for the Prevention of Famine in India."

We are indebted to Sir Charles Elliott, late Lieutenant-Governor of Bengal, who is well known as one of the highest authorities on Famine Administration in India, for a most valuable statement of the vast preparations rendered necessary to meet this national disaster, and of the lessons to be learnt from past visitations.

To MICHAEL FRANCIS O'DWYER, I.C.S., for his paper on "A Visit to Russian Central Asia."

Mr. O'Dwyer, of the Indian Civil Service, whose knowledge of the Russian language and of the Russian nation is considerable, favoured us with a very interesting paper on this important part of the world.

To SURGEON-MAJOR SIR GEORGE SCOTT ROBERTSON, K.C.S.I., for his paper on "Kafiristan: its Manners and Customs."

We were fortunate in hearing from Sir George Robertson—so specially known to us in connection with the heroic defence of Chitral—a full account of one of the most curious and interesting districts outside our north-west frontier of India.

To CAPTAIN P. MOLESWORTH SYKES, for his paper on "Kerman and Persian Baluchistan, with special reference to the journeys of Alexander the Great and Marco Polo."

Captain Sykes, H.B.M. Consul at Kerman, traced the steps of Alexander the Great and of Marco Polo in these desolate regions, by which he has greatly added to our historical knowledge.

In the Foreign and Colonial Section:—

To the RIGHT HON. SIR CHARLES DILKE, BART., M.P., for his paper on "The Progress of the British Colonial Empire during the Sixty Years of Her Majesty's Reign."

Sir Charles Dilke, one of the first to draw attention to the claims of Greater Britain to the consideration of this country, gave the Society, with which he has so long been connected, a masterly review of the development of our Colonial Empire during the past sixty years.

To JOSEPH G. COLMER, C.M.G., for his paper on "The Progress of Canada during the Sixty Years of Her Majesty's Reign."

Mr. Colmer, Secretary to the Dominion of Canada Agency, whose prize essay on the Union of the Colonies has received such high commendation, gave the Society a graphic and valuable account of the growth of the Dominion of Canada.

In the Applied Art Section:—

To W. H. ST. JOHN HOPE, M.A., for his paper on "The Artistic Treatment of Heraldry."

Mr. Hope explained to us, by the help of a beautiful series of specimens taken from famous buildings erected when heraldry was a living art, how admirably the details then lent themselves to artistic treatment, and how they may still be used with success.

To MATTHEW WEBB, for his paper on "Gesso."

We obtained from Mr. Webb an instructive demonstration of the decorative value of the beautiful art of "Gesso," besides a useful account of the materials needed and the mode of their application.

To Dr. J. W. L. GLASHIER, D.Sc., F.R.S., for his paper on "Delft Ware."

Dr. Glaisher, the distinguished mathematician, who is also a collector of examples of the interesting Delft pottery, gave us the benefit of his great knowledge of the subject in a valuable monograph.

[At the conclusion of the address, a series of lantern slides of colonial scenery was exhibited.]

Sir STEUART COLVIN BAYLEY, K.C.S.I., C.I.E., proposed a vote of thanks to the Chairman for his address, which was one which he felt sure must have suited all tastes. To those who found poetry in statistics and in the careful tabulation of figures, it would be an inexhaustible well of delight, whilst those who sought for simpler pleasures, and took their poetry in the more ordinary form, would find quotations to meet their taste. To all the subject was one of immense interest, and it had been dealt with in a manner which must have satisfied everyone. He must not omit, also, that their thanks were eminently due to the Chairman for the great trouble he had taken in placing before them the interesting views with which the address was concluded.

Sir OWEN ROBERTS, M.A., D.C.L., in seconding the vote of thanks, said this address had been a most inspiring one in many ways. Not only was the matter most excellent, but the easy manner in which it had been delivered gave it a great additional charm and made it much more enjoyable.

The motion having been put by Sir STEUART BAYLEY and carried unanimously,

The CHAIRMAN said he had to thank the members for the kind way in which they had listened to him, as well as for the vote of thanks they had been good enough to pass.

The meeting then adjourned.

Miscellaneous.

GERMAN COMMERCE.

The Foreign Office has communicated to the Society the report of Consul Wilfred Powell on the Association for the Promotion of Foreign Commercial Relations with Stettin, from which the following extracts are taken:—

Much has been said and written in Great Britain on the superiority of the German technical education to that of Great Britain, and to this has been, in some measure, attributed the success which has attended German commercial enterprise within the last 25 years. That the technical education is better than that of England is denied by many Germans who are competent to give an opinion, having studied the subject in both lands, but what they do admit is that the application of this education in Germany is carried out to a more practical and useful conclusion than in England.

Thus, in Great Britain there are numerous public and private schools having a modern side to their curriculum, which is an excellent adaptation of what is termed in Germany the "Real Gymnasium"; but in how many English schools is this modern side looked down upon by the head or high master, and consequently by the boys themselves, and the classic side held up as the education which befits a gentleman? Again, how many British boys on leaving school or the universities to face life in a business which is world-wide, can speak with fluency or even tolerably, any language other than their own?

Will the day ever come when educational establishments in Great Britain will be able to exchange pupils with equally respectable establishments on the Continent? For it is admitted on all hands that a language can only be learned to perfection in its own country; and in time of youth, as much can be learned in one year, as can be attained in three at a maturer age.

On the conclusion of the Franco-German war, a few leading merchants in Stettin, assisted by men of means, met to consider what steps could be taken to extend and improve the trade of Stettin with distant countries; for Stettin commerce up to that time had been for the most part confined to countries touched by the Baltic.

The first meeting of the Association was held in December, 1871, and at that meeting was established the "*Verein zur Förderung überseeischer Handelsbeziehungen.*"

It was decided that the best and most efficacious means of increasing Stettin's trade would be:—

1. The better education of clerks and young men who had taken up commercial business as a profession. For this purpose evening classes were to be instituted, and those who attended were to be instructed in all branches of commercial education: geography and science, also foreign languages, especially English, Spanish, and French. For private study a library was to be provided.

2. The sending to the British colonies, America, and other parts of the world, well-qualified clerks to improve their knowledge of business, and to work, at their place of destination, in the interests of Stettin trade. To carry this into effect, each young man so sent should receive a stipend not to exceed the amount of 1,500 marks, or about £75, to cover the expenses of travelling to and living for three months

in the country or place to which he desires to go, and has proved his fitness to proceed.

In most cases a letter is addressed to the Imperial Consul at the place or country to which the young man has departed, he also carrying a letter of introduction to the Consul, which he shall present with as little delay as possible on his arrival, thus being placed under the supervision of a recognised authority, who can advise and assist him in his career.

The Association began work in 1872 with great energy, competent masters were obtained for the English, Spanish, and French languages, as well as teachers in commercial subjects, and very considerable progress was made during the first year. Two gentlemen, both of whom were experts in foreign commercial knowledge, and one of whom was himself a great traveller, placed their experience and knowledge at the service of the candidates, and the Association grew to become a most useful institution.

Meetings are held in the evenings several times a month during the winter season, and the candidates are called upon to make lectures and reports upon every variety of commercial subject. I give a short list of some few of the subjects dealt with.

Morocco, sugar manufacture in Germany, German and American life, insurance companies, facilitation of the corn trade, the Mediterranean, Hong-Kong, the use of shorthand writing, voyage to San Francisco, iron trade, chinine, coal, Cameroons, New South Wales, Argentine, wool-growing, Sumatra, rights and duties of clerks, Transvaal, the Jesuit Mission in Paraguay, herrings, the Straits Settlements, tobacco, Brazils, Rio de Janeiro, do sailing vessels pay, journeys in Norway, England's advance in India, life and tobacco-growing at Sumatra, colonisation in sub-tropical countries, the opening of the North Pacific Railway, journey to Lagos, coffee plantation at Princes Island, Journey to Cape de Verd Islands, and very many others on equally various and useful subjects.

One of the principal duties of the young men sent abroad is to forward regular reports, if possible, once a month, or at the least, once every three months, in which they are desired to give a full account of what they have seen and done, and to give particulars of the commercial prospects and possible relations between their place of abode and Stettin. The most important points to which their attention is called, in making these reports, is to give details and particulars of the legislation, production, and consumption, as to prices of merchandise imported and exported, and also to give their views as to the means by which Stettin may be brought into commercial connection with the place on which they are reporting, or if there is already business connection, how this may be extended and improved.

These reports, which must be addressed to the "*Vorstand*" (Board of Direction), are read at the meetings, and are subjected to criticism and discussion. If they are considered of value they are printed with the annual report which is distributed to all subscribers.

I have seen many of these reports and some are excellent, showing that the writers noted with care and judgment the prospects of trade, and making frequent useful suggestions for the improvement of Stettin's trade relations, by which business men could not fail to profit. One clever report was on the trade with Jnhannesburg, dated 1895-96, advising Stettin business men, amongst other matters, to import cyankalium for clarifying gold, cloth and ready-made clothing, stating that the latter trade has hitherto been entirely in the hands of English firms, and showing how Stettin should be able to compete successfully with British exporters in cloth, &c., but adds, without giving a reason, that "an attempt to introduce German spirits would not be successful." The same report also recommends German farm labourers and artisans to come over, as they are sure to find ample employment, but cautions clerks against immigration, as large numbers are there at the present time without occupation and glad of employment as waiters.

Besides instruction in foreign languages (English, French, Spanish, and in some cases Portuguese) and being assisted to improvement in commercial knowledge, the candidates hear lectures and readings on all articles capable of export, of which they are expected to take notes. There is also an excellent library which is placed entirely at their disposal.

There can be no doubt that the large majority of those who have become members of this institution have turned out very well, and have not failed to remember the Association to which they owe their early commercial impulse. Several have shown this by substantial recognition, others by grateful letters received, and there can be no question that Stettin trade has been largely benefited by this system of emigration.

The following are some of the regulations in respect to the grants of money for travelling:—

Every member of the Association is entitled to apply for a travelling grant.

The applicant must prove himself to be possessed of sufficient knowledge of the French and English languages, as well as being well grounded in the business language of the country to which he is going (chiefly Spanish and Portuguese). His application, in which he states the amount required, must be supported by a written or verbal recommendation from the head of the firm in which he has hitherto been working, together with the report of the examinations which he has passed.

The grant to be advanced shall, as a rule, be only sufficient to cover travelling expenses, and such as are necessary for a stay of three months in the place to which the applicant is proceeding. The total, however, must not exceed 1,500 marks (about £75), unless a larger grant shall be allowed at a general meeting on the proposal of the board of direction.

Should the member so travelling obtain a situation before the expiration of the three months, and have a portion of the grant unexpended, he will be expected to refund the amount left. The board is not in any way bound to grant any member a second sum.

Those members who receive a grant, give a solemn promise, accompanied by grasping the hand of the president, that they will conduct themselves as worthy of the confidence and trust placed in them by the Association, and that they will make every effort to obtain as much information and knowledge as possible, to be employed and utilised to the benefit of the Stettin trade. They likewise promise to send once a month, if possible, but certainly once in three months a report to the board of direction on their experiences and impressions of the country to which they have proceeded, but especially to report upon the commercial aspect of affairs principally under the headings of consumption, imports, exports, climate, legislation, duties, prices, and to suggest any means by which their place of resort may be brought into business relations with Stettin, or if already in connection with Stettin, how such trade as exists may be improved and extended. These reports must be read at the general meetings of the Association, and shall be subjected to discussion. They may also be printed in the proceedings of the Association if considered of sufficient value.

It will be held as a matter of honour that those men who, having received a grant, have found a good situation abroad, and are in a position to repay the grant, should do so. These repayments shall be added to the capital of the Association, from the interest of which further grants can be made to others. There is no obligation under law to repay the grants.

In concluding these remarks upon what appears to me a most excellent and valuable institution, I think that something of a similar nature might prove of value in the education of British clerks and young men who are willing to become commercial travellers; indeed it should prove most useful to any young fellow, who, without the necessary means of his own, could by application obtain assistance from such an Association in Great Britain, and it also appears to me that there is even room for some extension and improvement on the Stettin method; this might be brought about by a society of merchants in Great Britain.

At all events any suggestion or information which may tend to the improvement of our trade abroad (from which the foreign middleman is, at present, a very considerable gainer) even of an indirect nature, should not be without its value.

MEMORIAL TABLETS.

The current number of the *Academy* contains an article on the memorial tablets of the Society of Arts, from which the following paragraphs are taken:—

A tablet has just been placed on the house at Hampstead in which Sir Harry Vane lived, and in which it is believed Bishop Butler wrote portions of his "Analogy of Religion." The circumstance is interesting; for from this house Sir Harry Vane—name beloved of every school-boy—was carried to

the Tower to be beheaded by order of Charles II. ; and it is probable that under the roof of Vane-house, as the place was called (it is now "Belmont"), Cromwell, Pym, Ireton, and Fairfax discussed ways and means; even Milton may have walked under the trees of its once noble grounds. But what of the series of tablets to which this Hampstead one has been added?

Thirty tablets may not seem much to show for thirty years' work. It is thirty years since the Society of Arts fixed its first Minton slab to Byron's house in Holles-street. One year, one tablet—this has been the average rate of progress. It seems slow; in reality, it is reasonable. The erection of these tablets is no more than an "odd job" in the work of the Society of Arts, yet the Society has not at any time flagged in its attention to this department. It has had to take rebuffs, and to abandon hopes, but it is always considering new proposals, and striving to bring them to successful issues. The difficulties of the work fully explain its slow movement, and are themselves interesting. In the first place, the number of London houses worthy to receive tablets is small. Scores of once eligible houses have clean disappeared, have not even left successors on their sites; these do not count. Then owing to the pranks that have been played with street names and numbers the difficulties of identification are immense.

A case is mentioned by the late Thomas Crofton Croker in a little book (notable for its beautiful thumb-nail woodcuts) called "A Walk from London to Fulham." Writing in 1860, Mr. Croker identified the house (No. 14, Queen's-buildings, Knightsbridge) as the residence of Mr. J. C. Nattes, an artist who is now forgotten. He was one of the sixteen artists who associated themselves together in 1805 to form the first exhibition of water-colours held in this country. Mr. Crofton had a hard task to identify the house; and well he might, for he tells us:—

"From 1792 to 1727 this house was described as No. 14, *Queen's Buildings, Knightsbridge*; but in the latter year the address was changed to No. 14, *Knightsbridge Green*. In 1800 it was known as No. 14, *Knightsbridge*, and in 1803 as No. 14, *Queen's Row, Knightsbridge*. In 1810 as *Gloucester Buildings, Brompton*. In 1811 as *Queen's Buildings*. In 1828 as *Gloucester Row*. In 1831 as *Gloucester Buildings*, and it has now reverted to its original name of *Queen's Buildings, Knightsbridge* . . . if, indeed the original name was not *Queen's Row, Knightsbridge*, as this, in 1772, was the address of William Wynne Ryland (the engraver who was hanged for forgery in 1783)."

Need more be said on the difficulty of identifying the residence of a genius in London?

A second set of difficulties which the Society of Arts has to meet are those connected with obtaining permission to place a tablet on a house at all. It must not be supposed that landlords or tenants are always eager to have a house honoured above its

fellows. Only one of Dickens's residences is marked with a tablet, and this, unfortunately, is the doomed Furnival's-inn. Permission to mark the houses he inhabited in Doughty-street, Devonshire-terrace, and Tavistock-street was sought in vain; and so you walk down Doughty-street trying to remember the number of the house in which "Oliver Twist" was written; and American visitors beat about the corner of Devonshire-terrace with interrogation in their movements, wishing to make sure that they see the house whence "David Copperfield" and the "Christmas Carol" went forth. It may be allowed that it is enough if one of Dickens's residences be marked; and, therefore, we hope that when Furnival's-inn—where "Pickwick" was written—has disappeared, some heart will relent, and a tablet be placed on one or another of the remaining homes of "Boz."

One feels a little bitterly the refusal of the Benchers of the Middle Temple to allow a tablet to be placed on Goldsmith's lodging at No. 2, Brick-court, where in his fitful gleams of prosperity he aped the hospitality of Reynolds and the grace of Beauclerk; where, too, he read *She Stoops to Conquer* to its first audience, the two beautiful Miss Homecks. The Benchers' refusal is the more strange because the tablet would have perpetuated the memory of Sir William Blackstone who lodged in the same building. But, then, Goldsmith's receptions disturbed the great lawyer; and perhaps the Benchers have not forgiven Nolly. The Temple is not the only Inn of Law which has excluded the tablets. Gray's Inn has been equally cold in the matter, though, if it chose, it might adorn its walks with tablets to the memories of Francis Bacon, Samuel Butler, Lord Macaulay, and other men of note.

THE PRODUCTION OF SPARKLING WINES IN GERMANY.

The making of sparkling wine in Germany has lately been brought to such perfection that German wines of all brands, from the most inferior to the finest sorts, now rank nearly equally with French champagne, added to which the price of the German product is considerably lower than that of the French. The value of the exports of sparkling wine from Germany in the eleven months ended November, 1896, amounted to £100,000, as compared with £95,000 for the whole of the year 1895. The export is chiefly to England, America, and Belgium. The British Vice-Consul at Cologne says that the belief, formerly very prevalent, that French champagne grew in the Champagne and was thus a natural product, whereas German sparkling wine was only an artificial one, may now be considered as set aside. Both descriptions owe their origin to art, and both are produced according to one method, the French method of manufacture having been adopted in Germany. This was rendered all the easier owing to the fact of the largest champagne businesses in France

being partly in the hands of Germans (Roederer, Mumm, Heidsieck, &c.), and being partly managed by Germans, which is still the case. In the manufacture of sparkling wine all sorts of grapes can be used, but the early and late Burgundy and Klebroth are chiefly used as being the best adapted thereto. They require, however, to be pressed immediately upon being gathered, in order that the colouring matter may remain in the skins. After pressing, the must is put into casks, where it remains until fermented. Then a *cuvée* is formed, which means that different wines are mixed together in order to obtain a larger number of bottles of one class. Now comes the filling of the bottles, each bottle receiving the addition of a certain amount of sugar, in order to produce within the bottle itself a second fermentation, developing carbonic acid and alcohol. The bottles are placed in the cellar in such a position that the sediment forms at the bottom. When this is effected, which requires several years, then the position is again altered in such a manner that the sediment leaves the bottom and forms on the cork, for which frequent shaking of the bottles is necessary. When the sediment adheres to the cork, then follows the concluding process of the wine, at which each workman has his special task. The *dégorgeur* uncorks the bottles by which the carbonic acid carries off the sediment; the *opereur* measures the dose, which means giving to each bottle the fixed addition of liqueur; the *recouleur* fills up the bottles with wine of the same sort; the *boucheur* recorks; the *ficeleur* ties the cork down with pack thread; and the *ficeleur au fil de fer* fastens on the wire. Each operation in the preparation of sparkling wine demands peculiar dexterity, for which reason, in large factories, the hands are specially trained. A chief point in the making of sparkling wine is the preparation of the liqueur, the characteristic properties of the wine depending upon it. Each sort requires a special composition, the taste of the consumers and the price of the wine deciding the point. The preparation of the liqueur itself is the secret of the manufacturers.

General Notes.

PRESERVATION OF FRESH GRAPES.—A recent bulletin of the School of Agriculture of Scandicci, Italy, describes experiments made by Professor Marchi for the keeping of grapes fresh during the winter. A certain quantity of grapes, comprising different qualities, was hung up in a cool and dry place, all damaged berries having been previously removed, and a second lot was packed in dry pulverized peat in wooden boxes. At the end of four months the grapes that had been hung up had become decayed, and had dropped off; on the other hand, those that were

packed in the boxes were found to be in an excellent condition. This is therefore a simple and economical method. Another one consists in gathering the bunches with some of the stem attached, and immersing their tips in bottles containing water and pulverized charcoal. Experiments were also made for preserving seed potatoes by using corn chucks, sawdust, peat, and very dry sand. The three first-named gave the best results, while the sand proved a failure.

MEETINGS FOR THE ENSUING WEEK.

- MONDAY, NOV. 22.** Imperial Inst., South Kensington, 8½ p.m.
Mr. Eric Bruer, "Electric Balloon Signalling applied to Scientific Exploration in Arctic and Antarctic Expeditions."
Surveyors, Savoy-street, W.C., 8 p.m. Mr. J. D. Wallis, "The Manchester Ship Canal Compensation Cases."
Geographical, University of London, Burlington-gardens, W., 8½ p.m. Dr. Sven Hedin, "Four Years' Exploration in Central Asia."
Medical, 11, Chandos-street, W., 8½ p.m.
Sanitary Institute, 74A, Margaret-street, W., 8 p.m.
Mr. Charles Mason, "Scavenging and the Disposal of Refuse."
London Institution, Finsbury-circus, E.C., 5 p.m.
Mr. Arnold Mitchell, "Peterborough Cathedral and its Restoration."
- TUESDAY, NOV. 23.** Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.
Civil Engineers, 25, Great George-street, S.W., 8 p.m., Mr. W. S. Greslee, C.E., "Central Station Electric Coal Mining Plant in Pennsylvania."
Photographic, 12, Hanover-square, W., 8 p.m., Mr. Eric Stuart Bruce, (i.) "Photographs of the Optical Projections in Space produced by the Aerial Graphoscope." (ii.) "Probable Projection Lightning Flashes, Illustrated by Experiments and Photographs."
Anthropological, 3, Hanover-square, W., 8½ p.m.
- WEDNESDAY, NOV. 24.** SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Prof. James Douglas, "The Progress of Metallurgy and Metal Mining during the last Half Century."
British Astronomical, University College, W.C., 5 p.m.
- THURSDAY, NOV. 25.** Royal Burlington-house, W., 4½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 6 p.m., Mr. Frederick Villiers, "With Greek and Turk during the Recent War."
Sanitary Institute, 74A, Margaret-street, W., 8 p.m.
Professor Henry Robinson, "Sewerage and Sewage Disposal."
Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Renewed discussion on Mr. L. Epetan's paper, "Accumulator Traction on Rails and Ordinary Roads."
- FRIDAY, NOV. 26.** Clinical, 20, Hanover-square, W., 8½ p.m.
Physical, Chemical Society's Rooms, Burlington-house, W., 5 p.m.
- SATURDAY, NOV. 27.** Botanic, Inner Circle, Regent's-park, N.W., 3¼ p.m.

Journal of the Society of Arts.

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FRIDAY, NOVEMBER 26, 1897.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****INTERNATIONAL CONGRESS ON TECHNICAL EDUCATION.**

The Report of the Proceedings of the International Congress on Technical Education, held at the Society of Arts in June last, has now been published—price 3s. 6d., by post 3s. 10d., and can be obtained on application to the Secretary, Society of Arts, John-street, Adelphi, London, W.C. The volume consists of 307 pages, and contains a report of all the papers read and the discussions, with appendices giving lists of officials, delegates, and others taking part in the Congress.

Proceedings of the Society.**SECOND ORDINARY MEETING.**

Wednesday, November 24, 1897; Professor A. K. HUNTINGTON in the chair.

The following candidates were proposed for election as members of the Society:—

Davies, W. J., Tupsley-lodge, Hereford.

Gandil, Viggo, care of Messrs. Bewicke and Wulffson, Vancouver, British Columbia.

Maitland, Major-Gen. Pelham James, C.B., United Service Club, Simla, India.

Sutherland, Sir Thomas, G.C.M.G., LL.D., M.P., 4, Buckingham-gate, S.W.

Webster, John J., 39, Victoria-street, S.W.

Wells, Henry Hallifax, 16, Paternoster-row, E.C.

Wells, William James, Beechurst, Kingswood, Reigate, Surrey.

Wilson, John William, Drewton Stray, South Cave, Yorkshire.

The paper read was—

THE PROGRESS OF METALLURGY AND METAL MINING IN AMERICA DURING THE LAST HALF-CENTURY.

By JAMES DOUGLAS.

The commencement of her Majesty's reign is a fitting epoch from which to date the pro-

gress of any of the industrial arts on both Continents, for it virtually coincides with the commencement of railroad building. It was in 1829 that the Liverpool and Manchester railroad called for that competitive test which produced Stephenson's "Rocket," the first locomotive of the modern type; and it was within the same decade which saw her Majesty ascend the throne, that the Stephensons shipped to the United States the locomotive "Stourbridge." The Baltimore and Ohio railroad was opened for travel from Baltimore to Ellicott, thirteen miles, on the 24th May, 1830; and the Mohawk and Hudson River railroad, the first section of the present consolidation known as the New York Central and Hudson River, was opened for traffic on the 12th September, 1831. The progress of modern mining and metallurgy and of railroad building have everywhere followed parallel lines, but nowhere more accurately than in North America, where the immense distances to be spanned between the points of production and the centres of consumption, and even between the ores and the fuel, could only have been traversed by steam transportation.

MEXICO.

If we travel northwards in our retrospect, Mexico first claims our attention. The third decade of our century was not distinguished by any notable industrial event in Mexico. It was not till much later that the first railroad connecting Vera Cruz with the capital, was built with English money. The Republic was still in the throes of that transitional revolutionary period which intervened between the overthrow of the Spanish colonial rule and the establishment of the stable Republican Government which now exists. As transportation was costly, the precious metal ores were the only ones extensively mined, and they could be extracted only by methods involving a consumption of little or no fuel. Reliable annual statistics are not available for the first half of the century. The average annual amount recovered is, however, generally placed at 12,000,000 ounces of silver and 1,000,000 of gold. Chevalier and Duport put the Mexican yield of silver in 1840 at 1,650,000 lbs. troy (Whitney, p. 183). The gold production was certainly not much in excess of 1,000,000 dols. Well nigh all this came from ores which would give up their metal to the *patio* process, as it required neither fuel nor steam power for its successful operation. Where lead ores were smelted, this operation was effected in small

adobe furnaces, either for the recovery of the associated silver ore or the collection of silver from refractory ore. The bullion was always cupelled on primitive hearths, and the litharge returned to the cupola. In 1896, silver was extracted to the value of 58,861,693 dols. at Mexican valuation. Of this, 18,253,969 dols. were exported out of 21,092,397 dols. coined, 21 per cent. of the silver was exported in ore and matte, and 41 per cent. in bars and lead bullion (British Consular Report, No. 1985).

Mexico's large lead production has of necessity followed the introduction of railroads. The birth of the industry dates back only some fifteen years. Its development is due entirely to American enterprise, and it was stimulated at first by the scarcity of lead for the collection of silver from dry ores in the United States. But the heavy duty, which subsequently came to be imposed on lead entering the Union, checked the importation of ore into the States, and compelled the establishment of large smelting works with modern furnaces in Mexico itself. At present there are six modern lead smelting establishments in Mexico—two in Monterey, one of which is owned by the Messrs. Guggenheim, and the other by a Mexican company; one in San Louis Potosi; one in Valladolid; one in Aguas Calientes; and one in the Mapami district. Their gross production is about 7,000 tons of pig lead monthly. In addition, over 6,000 tons monthly of ore are exported to the States, chiefly from the Sierra Mojado and from the famous old group of mines, known as the Santa Eulalia, near the city of Chihuahua. The district of Guerrero is giving promise of being a large producer. Lead ores are mined in greater or less quantities at innumerable other points, and still treated in small native furnaces. But where ores are within reach of railroads or ocean transportation they are preferably exported. The exclusive fiscal policy of the United States, and the decline in the price of silver, have combined to retain the smelting industry of lead in Mexico to the notable advantage of the Republic. The United States Customs returns show a value of lead in pigs, bars, and so on, imported in 1895 from Mexico, of 2,496,689 dols., on which duty at an *ad valorem* rate of 47·23 per cent. was collected; and in 1896, 1,906,097 dols., on which an *ad valorem* duty at 51·75 per cent. was collected. Calculating lead at 3 cents per lb., this would represent an importation of about 41,000 short tons into the United States, on which duty was paid. On

the other hand, the British Customs returns give the import into this country from Mexico, of only 370 tons of lead ore, and no pig lead, though 30,426 tons of pig lead appear as imported from the United States. This is presumably Mexican and British Columbian lead, which was smelted and de-silverised in the United States in bond.

Copper mining in Mexico, fifty or sixty years ago, was even more restricted than that of lead, by defective means of transportation. There exist no statistics to show what her production then was; it was, however, very small—limited to what was required for the scanty needs of the people, and the demands of the Mints. Copper was probably mined on the Gulf of California, where the present Boleo Company now has its magnificent establishment, for water facilities of transportation there allowed of the exportation of the ore. Small quantities of oxidised ores were also extracted from the Ajo and other mines to the east of the Colorado river. Native copper was gained from the Santa Rita mountains, in what is now New Mexico, and there was a large smelting establishment near Mazapil, in the State of Zacatecas, to which the rich carbonate outcrop of the Aranzazu Mine has supplied ores for a century or more. Copper was also smelted with their usual skill, though on a very small scale, by the metal workers of the State of Michoacan, from the large deposits of low grade ore which are now reattracting attention; and also at Aguas Calientes, where operations are being revived on a very different basis. At innumerable points sulphurets of copper were extracted in limited quantities to supply the *magestral* to the *patio* heaps. Copper mining was, however, not a prominent industry, nor can it yet be said to be so. The largest copper producer by all odds is the French Company of Boleo already referred to, which made last year 9,940 long tons. The copper mines of Mazapil are being worked more actively than of old; the Candela Mines in the State of Leon are producing more than they did; the Messrs. Guggenheim have works at Aguas Calientes, where they use the copper of the old abandoned mines to collect the gold and silver ores gathered thither from many points. Copper mines are being opened in Sonora, and with railway extensions to other points, mines now known to exist, but too inaccessible, will be reached. But no deposits of menacing magnitude have been discovered, or are likely to be opened within a measurable period of time.

Tin is another metal which has also been a product of Mexico since the early Spanish period. In the Central States, but chiefly in Durango and Zacatecas, isolated rich bodies of casiterite in felspathic rocks, and rich placers of limited depth and extent have, from time almost immemorial, yielded what tin the country could consume. The ore was and is made into fairly good metal in small *adobe* cupolas. Many attempts have been made to initiate operations on a large scale, but the supply has always proved to be deficient.

As yet Mexico is dependent on foreign sources for her supply of iron and steel. Near the city of Durango is the famous Cerro Mercado, one of the most magnificent iron deposits in the world, but the fuel, which is as necessary as the ore, is not at hand. The rocks which make her rich in gold and silver along the central plateau, unfortunately do not contain coal. But Mexico is not entirely deprived of this most essential auxiliary to metallurgical industry. Within the period under review, though in fact it has been within the last fifteen years, or since railroads have penetrated the country from north to south, and a stable government has assured security to life and property, Mexico has made immense strides. Her silver production has grown from about 12,000,000 ounces in 1837 to 50,000,000; her gold from 1,000,000 dols. to 6,000,000 dols.; her lead from an inappreciable amount to about 50,000 tons, and her copper from insignificance to about 12,000 tons; and what has been done gives but a forecast of what will yet be accomplished.

UNITED STATES.

GOLD.

In 1837 gold mining was confined to the Southern States, where, chiefly from placers, about 1,000,000 dols. a year was, during this decade, extracted. This small yield declined immediately afterwards, to be increased slightly under the spasm of excitement in gold mining which followed the discovery of gold in California, only again to sink to an insignificant figure. Even to-day, with all the advantages of railroad transportation, chlorination methods, good quartz mills, dredging machinery for handling the sands in river bottoms, the gold production of the south reaches only 250,000 dols. annually.

But a very different fate attended gold mining in the West. It also has suffered its ups and downs and a line, expressing production dia-

grammatically, shows very sudden curves due to the discovery and the rapid exhaustion of some one or another of the great alluvial deposits which have been found at intervals of time between the first strike on the American River at Sutter's Dam, in 1848, to the present extraordinary find in Alaska. This last may prove to be unprecedented in richness, but as yet there is no proof that it is. Mr. T. B. King, the special agent sent by the United States Government to report on the gold discoveries of 1848 and 1849, estimated that not less than 40,000,000 dols., were extracted almost exclusively from the tributaries of the Sacramento; and by November of the year 1848, in which the gold was discovered, the Rev. C. S. Lyman ("Silliman's American Journal," vol. vii., p. 291), who was on the spot, considered that between 4,000,000 dols. and 5,000,000 dols. had been washed out, at the rate of from 30,000 dols. to 40,000 dols. daily, by some 4,000 labourers (Whitney's "Metallic Wealth of the United States," pp. 126 and 137). With the exhaustion of her rich placers the California yield fell off after 1851, but Whitney (p. 147) estimates the grand total of the gold extracted from the California sands and quartz veins, from 1848 to the end of 1853, at not less than 260,000,000 dols.* Nor is this a unique example of sudden oscillations in production from a rapid exhaustion of old alluvial deposits, and the discovery of others. In 1859, the statistical tables show a notable falling off, but there is a sudden rise in 1860 and the following years. This was due in a great measure to the yield of the placers of that part of Idaho which, in 1864, was constituted the Territory of Montana. W. C. Keyes gave the gold production in 1863, chiefly from Bannock and Alder Gulch, at 8,000,000 dols.; in 1864, from the same limited areas, 16,000,000 dols., and from 1865 to 1867 he gave the yield from Helena, Confederate Gulf, and Blackfoot as 37,550,000 dols. (Blake's "Report on the Precious Metals," p. 40). It is clear, therefore, that such phenomenally rich placers as those now being discovered and exploited in Alaska are not without parallel in the history of alluvial gold mining on the North American Continent.

But the steady maintenance of a large

* Blake, in his "Report on the Precious Metals," 1860, quoting from the *San Francisco Herald*, as repeated in the *London Times*, gives the production of gold in California from April 1, 1849, to Dec. 31, 1850, at 68,587,591 dols. He adds "The Custom-house returns were burnt, and these figures thus have a particular value."

gold production from the United States, despite the exhaustion long ago of its rich alluvial gravels, and the curtailment of about 5,000,000 dols. a year through the Debris Legislation of California, which virtually stopped the exploitation of the old river beds by deep hydraulicking, has been due to the application there of undaunted courage in mining, to ingenuity and skill in using every possible mechanical appliance which would cheapen the labour item of cost and increase the output, and not a little to scientific acumen and research in improving metallurgical methods invented by others. The decline of late years in the price of silver has diverted from silver mining to the exploitation of old and new gold deposits a large army of prospectors—the men to whom the United States owes—though they are not technically trained, perhaps because they are not technically trained—the rapid progress which has been made in the discovery of its buried resources. There have not been made any notable discoveries, apart from Alaska; but the gold production has been increased in almost each of the Western States and Territories by the revival of mines abandoned when the cost of extraction was higher than it is now, and by doing that slight amount of initial work on new discoveries which is all the prospector can do towards finding the purchaser and opening a mine. As it is, the cost of mining and milling has been reduced to so low a figure where the ore bodies are large and the ore neither very hard nor refractory, that there is not much margin for further reduction. Leaving out of account such an extraordinary record, due to exceptional conditions, as that of the Spanish gold mine, California, which made a profit on ore, netting only 60·6 cents. per ton, we have the records of the Treadwell Mine, Alaska, which mines and mills ores yielding a large proportion of sulphurets, which must be chlorinated, for 2 dols. 50 c., and the Homestake group of mines in Dakota, where the cost of treatment, owing to the high price of both fuel and labour, is heavy, and where, nevertheless, an ore netting above 4 dols. has been for many years handled to a very heavy profit. The yield of gold from copper is yearly increasing as the cost of separation by electrolytic methods is being cheapened.

American types of machinery and mechanical methods have been now adopted, and the gold mills made in America are now being shipped the world over. American metallurgists cannot claim the credit of any valuable chemical

discoveries in the field of gold metallurgy, but they have extended the utility of such processes as the Plattner by devising machinery and furnaces for its cheaper application. It is in this direction that the greatest advances have been made, for thither American metallurgists have been driven, not only by the insatiable demand for quantity but by the high cost of labour. As coal comes to be more widely and cheaply distributed, and improved metallurgical methods more universally applied, the gold production of the United States will certainly be more than maintained; for few of the larger and more important gold veins or deposits show signs of exhaustion in depth. It is due to these healthy causes, not to any great discoveries, that the gold production has increased from 36,000,000 dols. in 1893 to over 52,000,000 dols. in 1896, and that during the past 60 years the United States has added to the currency of the world about 2,000,000,000 dols. worth of gold.

SILVER.

The history of silver in the United States during the latter half of our century, has been much more exciting, and its production has been subject to much greater vicissitudes than that of gold. Till the discovery of gold in California, all the silver made was a trifle from some rich lead ore in Lancaster and Chester counties, Pennsylvania, and Davidson county, North Carolina; a very small quantity, selected from the copper of Lake Superior, and what was alloyed with southern gold—altogether an amount not in excess of 4,000 ounces annually. But from 1848 onwards silver figures as an important item of production, though till the Comstock rose into prominence very little silver was recovered directly from silver ores (Whitney, pp. 180 and 183). Whitney credited the United States with only 277 to 430 lbs. troy per annum between 1841 and 1848, and Whitney wrote in 1854. Raymond, on the other hand, gives an annual production of 38,673 ounces for every year from 1845 to 1857. At any rate, so marked was the discrepancy between the production of gold and silver that Whitney, writing in 1854, indulges in soothsaying, and suffered the usual fate of the prophet. He says:

“If we compare the produce of the two metals we shall have the following results:—

Year.	Relative weight of	
	Gold.	Silver.
1800.....	1	43
1845.....	1	17
1850.....	1	8·8
1852.....	1	4

"The effect of this extraordinary change in the relative production of the two metals has been felt everywhere. Already gold has driven silver out of the field in those countries where it was before the principal medium of circulation. That which has thus been withdrawn as coin, has been partly brought into use again in the form of plate; but a large part has been shipped to Asia. Up to this time there has been no very considerable change in the relative value of the two metals; but should California and Australia continue to supply gold at anything like the present rate for some years to come, it seems impossible that such a change should not take place. As this metal rose, while the Mexican and South American mines were pouring out their treasures, from a value only ten times as great as that of silver to that which it now has—of between 15 and 16 to 1 of the latter metal—so now there is no reason why it should not gradually return to something like its former ratio.

"Silver is in a geological point of view the metal best adapted for a standard of value, since, possessing all the valuable qualities which make gold suitable for that purpose, it is not liable to those fluctuations in its production to which this latter is exposed. There is no discovery of a new continent to be looked forward to, whose mines shall deluge the world with silver, and any increase in the amount of this metal produced must come chiefly from the working of mining regions already known, by the application of increased skill and capital. As it is obtained mostly from mines wrought in the solid rock, any additional development they may acquire must be gradual, while gold, from the very nature of its occurrence, can never be produced with that steadiness which characterises the metals wrought chiefly in deep and permanent mines."

Within two years of the date of this prophecy, the United States was turning out 2,255,000 ounces of gold, 8,500,000 ounces of silver; and twenty years subsequently the gold production had fallen to 1,670,000 ounces, and the silver ran up to 28,800,000 ounces, of which about one half came from the Comstock lode alone. Twenty years still later, the gold production was almost constant, but the silver production had swollen to 65,000,000 ounces, though the Comstock had long ceased to be a notable factor, and but a small fraction of this immense total came from any mines in which silver and gold were the sole elements of value. The date of silver production then commenced to turn, and is, of course, now run down with furious speed. With silver above 60 cents, it would seem that the mines of Park City Utah, and some of the Leadville mines, could maintain existence on a very profitable basis, but at the present price some have been compelled to close, and others are running on narrow margin.

The first strong impetus to silver mining was given by the discovery of the Comstock in 1859, and the mines of the White Pine and other districts in Nevada. They all yielded dry ores, amenable to milling processes, and for about 10 years from that date little or no silver was extracted by any other method than pan amalgamation. But the discovery of rich bodies of argentiferous lead in the Eureka district of Nevada, and in the Wasatch range of Utah, in the sixties, led to the introduction of smelting, at first for the recovery of the baser as well as the more precious metals which the ore itself contained, and subsequently as a means of collecting the silver and gold from dry ores, through the agency of the lead. The opening up of the lead mines of Leadville in the early sixties afforded such a large supply of smelting ores within reach of the coking coals of South-Eastern Colorado, that smelting rapidly superseded both milling and leaching in Colorado, the more readily as nowhere did pan amalgamation without preliminary calcination secure anything approaching to a close extraction. The mills on the Comstock recovered only about 65 per cent. of the gold and silver, and during its palmy days they threw into the tailing piles not less than 8,000,000 dols. annually. So completely has smelting superseded other methods that Rothwell ("Mineral Industry," vol. v., p. 242) estimates that not more than 4,000,000 ounces, out of a total of 58,488,000 ounces of silver extracted in 1896, were recovered by pan amalgamation and tank lixiviation.

The two methods, namely, milling and smelting, and the manner of practising them, are vividly illustrative of the defects and the merits of American metallurgy. The Comstock, White Pine mines, and other Nevada deposits were of such exceptional magnitude and richness that in a few years they peopled the desert of Nevada, which had been part of the territory of Utah, or Deseret, with a population sufficiently dense to entitle it to statehood. In 1880 the population of Nevada was 62,266. Ten years afterwards it had declined to 45,761; and the extravagant haste with which the Comstock lode was worked is indicated by the fact that of the 348,000,000 dols. of gold and silver extracted from it between its discovery in 1859 and 1890, 274,000,000 dols. or 79 per cent., were recovered in sixteen years, or between 1862 and 1878. And yet, as this enormous sum represents only 65 per cent. of the total mined, 156,000,000 dols. were

recklessly run out of the mills, of which a trifle, at best, will ever be saved from the tailing piles. The Washoe process in conjunction with the stamp mill was one of the many innovations introduced on the Comstock. It is an adaptation of the slow *pateo* process to the demands for speed which American energy and impatience, and the modern craving for large returns, made on the metallurgist. But celerity and enormous output were in this, as in every case, secured for a time at least, at the expense of unjustifiable waste. Were the Washoe method still as widely used as it was, experience would have remedied its defects, and rapidity would have been attained without making so ruinous a sacrifice, for that has certainly been the result in the field of argentiferous lead smelting, which has almost everywhere supplanted milling. In the early period of smelting in Utah and Colorado, when the ores were rich and abundant, furnaces large for that day were used, and the charges were put through without much regard to scientific mixtures and slag contents, the supreme object being a large bullion output. But to-day, while the works have grown in size, the furnace in dimensions, and the tonnage treated per stack increased in quantity, the Western lead smelter can challenge comparison of his work with that of the oldest European establishments, both in the matter of saving and of cost. He has learnt to correct the defects of his early rule of thumb practice, and to run his furnace on carefully calculated charges, while nevertheless not forfeiting the great economic advantages which accrue from treating large quantities, both in the aggregate and per furnace. That he can afford to offer the miner, in some cases, 20 dols. per ounce for his gold, and 95 per cent. of the assay value of his silver, and 90 per cent. of the lead, and that he has reduced the charges on silicious ores to 7 dols. (equal to 28s.), and about 4 dols. (16s.) per ton on neutral ores, is proof not only of the cheapness with which he works, but also of the closeness of his extraction.

NOTE.—The smelting situation in Colorado at the present time is as follows:—There are being smelted, by the three smelters in Pueblo, about 1,500 tons daily of ore; by the three smelters in Denver, 900 tons; by the two smelters in Leadville, 900 tons; by the smelter in Durango, 130 tons; by the smelter at Silverton, 100 tons. The treatment charges on the ore smelted vary very materially.

For silicious silver ores, averaging about 65 per cent. excess silica, the smelters pay for

95 per cent. of the silver.

\$19 X per ton for gold if .05 ozs. or over, and from \$7 to \$9 X treatment charges.

On gold ores from Cripple Creek district:—

\$20 X per oz. for gold.

\$10 X treatment charge.

On lead ores from Idaho:—

95 per cent. of the silver.

90 per cent. of the lead.

\$7 X treatment.

Sulphide ores:—

95 per cent. of the silver.

\$19 X per oz. if .05 or over.

\$7 X treatment charge.

Neutral 15 cents allowed for excess iron, and 10 cents charged for the excess silica.

Our iron ores are usually bought free on board cars at Leadville, the smelters paying:—

95 per cent. of the silver, and an average of

75 cents per ton treatment charge on a 40 per cent. excess iron basis.

Some smelters are running full, others only up to 50 per cent. of their capacity. The effect of the Leadville strike has been less notable in diminishing the quantity of ore smelted than in obliging the smelters to pay better prices for iron ore and sulphides from the Leadville district, in order to encourage the production of lower grade material.

For a long time past he has been embarrassed by shortage of lead ore in comparison with the quantity of dry gold and silver ore treated. This has been the case to such an extent that it has not been unusual to run on an eight to ten per cent. lead charge. The great decline in the price of silver will unquestionably still further reduce the production of argentiferous lead ore in the Western States; but, unless silver drops to a point which will dislocate Mexican finances, the economy of operating a mine in a silver country and selling the product in a gold country will stimulate the export of lead ores to the United States, notwithstanding the heavy import duty—more especially if that lead be re-exported and a rebate of the duty thus secured. As it is, the lead production of the United States from native ores was in 1896 probably 174,692 tons, of which 130,000 tons were extracted from pure non-argentiferous ores. The amount was large, but utterly insufficient to supply the demand; for though in 1896 64,885,202 lbs. were exported, 187,522,267 lbs. were imported.* Importation from abroad is therefore necessary, and the foreign supply can most advantageously

* "Statistical Abstract of the United States for 1896," pp. 187 and 215; and "The Foreign Commerce and Navigation of the United States for the year ending June 30, 1896," p. 148.

be drawn as ore from her neighbours Mexico and Canada. The Customs returns for 1896 show that between six and seven thousand tons of lead came into the United States from Canada, and the balance from Mexico, the Canadian ores coming exclusively from British Columbia. It may seem disparaging to Canadian and British enterprise that raw ores should be allowed to leave Canada, and thus the advantage of its local treatment be lost to the country that produces it. But the river and lake system of Southern British Columbia is such that the readiest outlet is to the United States; and moreover argentiferous lead ores, unless of most desirable composition, can only be treated with a maximum of economy and accuracy of saving when a mixture can be secured, and this is best effected when supplies are drawn from many sources. When the Crow's Nest Pass branch of the Canadian Pacific is finished, especially if the coalfield it traverses yields a good coke, it should collect the ores of the eastern loop of the Colorado, of Kootenay Lake, Rossland, and the Boundary districts, and make it advantageous to operate large metallurgical works for the smelting of both copper and lead ores, carrying the precious metals at points north of the boundary line.

While the collection of gold and silver by lead, and their subsequent separation has been practised from time immemorial, it is only of late that methods of separating the precious metals from copper have been so improved and cheapened as to enable small quantities of gold and silver to be profitably saved from that metal, and to induce metallurgists to use it extensively for collecting them from non-cupriferous ores. The quantity of gold and silver which now comes into the market as a by-product from copper ores which without them would pay for treatment, or from copper ores which without these auxiliary metals would be rejected, forms a very large and rapidly increasing item in the world's total.

The electrolytic method, though the last introduced, is now the most generally used. It, and the Bessemer converter, which affords so rapid and cheap a process for reducing mattes to metal, have been the most potent agents recently in affecting the metallurgy of copper and the precious metals. Neither of these improvements owes its origin to the United States, but both are practised there on a scale which dwarfs all similar operations elsewhere. The statements

of the Anaconda Copper Company of Butte show that they shipped in 1896, 132,364,198 lbs. of copper, 20,380 ounces of gold, and 6,200,000 ounces of silver; or .34 ounces of gold and 104.7 ounces of silver to the ton of 2,240 lbs. of metallic copper. The day has not long passed when it was not considered profitable to save the precious metals unless they exceeded in value two shillings to every unit of copper. Now when the higher selling price of deposited copper over casting brands is taken into account, a copper containing not over 6d. in gold and silver to the unit of copper can be advantageously treated electrolytically. As this small quantity of gold and silver is associated with the major part of the world's copper, the quantities of these two rarer metals which thus enter commerce as by-products is to-day large, and as electrolytic methods are improved, will become even larger. And therefore, just as a small trace of silver which has now for the last century been extracted by the Pattison process from lead, has yielded a notable portion of the world's supply, so, in future, copper may be counted on to replace a considerable share of the silver which the closure of some of the silver mines, owing to the low price of that metal, may cut off.

The silver miner, as well as the silver metallurgist, has not been wanting in originality. It was in extracting the wide ore bodies of the Comstock that the system of timbering in square sets was first used. The speed with which the Sutro-tunnel was driven to tap the Comstock lode was attained only by using power drills; and when the tunnel was completed, the Comstock was, I think, the scene of the first electric plant, stationed underground, and run by the head of water descending the shaft. It has, in many respects been the stage on which many notable experiments and much actual advance in mining and metallurgy has been made.

COPPER.

The metal whose discovery and production in the United States within the past sixty years has exerted most influence on the Metal Exchanges of Europe is copper. At the commencement of the period in question, a very small quantity, estimated at not over 100 tons in fine copper, was mined in the Atlantic seaboard States. The existence of native copper on Lake Superior had long been known, but it was not till Dr. Houghton's partial though systematic survey of the rocks of the Keewenaw

promontory had been made that mining was attempted. The first mine opened was the Cliff, in 1843-44, and some 12 tons of metallic copper were produced; but year by year, with few relapses, the quantity of copper, extracted at first from veins only and latterly entirely from the beds of conglomerate and amygdaloidal trap, has grown till in 1896 the Lake Superior mines put into the market 64,312 long tons of copper famous for its purity. The metallic condition to which nature has reduced the copper in the ore so facilitates its extraction that a simple concentration and a single fusion in a reverberatory furnace suffices to convert it into metal of the very highest grade. There has, therefore, been little room for radical changes in the method of their treatment; but the wonderful development in the mechanical appliances employed may almost be measured by the difference in the capacity between one of the old up and down wooden stamp-heads originally used, and which could not crush more than a ton a day, and a steam stamp-head of to-day with its daily capacity of 250 tons. The Lake has also been the scene of much heroic mining. The Tamarack Company set the example of fearlessly sinking for their copper deposit in depth by starting a shaft 2,270 feet deep, to tap the conglomerate below the Calumet and Hecla workings, but since then the Calumet and Hecla Company has opened up their ground on the dip of the bed below the level of the Tamarack workings, and are extracting ore through their Red Jacket shaft from a vertical depth of 4,900 feet. While the Calumet and Hecla conglomerate has been the most productive, the most striking instance of cheap mining and milling is afforded by the Atlantic Mining Company working on a softer trap bed of large uniform width and of very uniform, though exceedingly low, yield in copper. Their accounts show that the returns of copper to the ton of rock over a period of years is only 14 lbs. or 7-10ths of 1 per cent., and that the total cost of putting it into market as refined ingot is on an average 1 dol. 23 cents per ton of rock mined. As even Calumet and Hecla ore yields only about 3 per cent., the Lake copper mines can be profitably worked only when large quantities of ore are automatically handled; and once operations attained a certain range it seems inevitable that they will be increased until either the ore be exhausted or the works become unmanageably bulky.

While copper mining on the Lake was

assuming significant proportions, deposits of sulphuretted ore were opened in Vermont and at Ducktown Tennessee, and at many other points in the Appalachian Range. The operations in these districts were then looked upon as extensive, though judged of by the standard of to-day they were small, and their smelting plants and methods followed closely German models. At that period also, that is before the war when the Liberal trade policy of the United States permitted of a freer interchange of products with South America, the ores from Chili were smelted in considerable quantities at copper works in New Haven, Perth, Amboy, and Baltimore. The war tariffs, of course, cut off these supplies; but the intense business activity which followed the war stimulated mining at home, and led to the rapid opening up of the West by railroads. They alone have made possible the predominant position the United States now occupies in the copper trade of the world through the development of her Rocky Mountain mines. When the business revival of 1879 occurred after the long depression following the Jay Cook collapse of 1872, the United States was obliged to import copper, but ever since then her exports of that metal have increased, till in 1879 they reached 125,851 tons, or about one-third of the total production of the world.

Arizona was the first of the Territories to draw attention to the copper resources of the West; but her mines, though they have steadily increased their output, have been obscured by the wonderful performances of the copper companies of Butte, Montana. Last year Montana produced 102,203 long tons of copper, the Lake 64,312 tons, and Arizona 32,922 tons; and approximately the number of tons of ore handled were, in Montana 2,500,000, on the Lakes 2,500,000, in Arizona 1,000,000, and elsewhere 1,000,000, making a gross tonnage of more or less 7,000,000, or about 45 per cent. of the tonnage of the iron ores of the United States. To raise this the best machinery is used. The most powerful hoisting plant is, I believe, that of the Calumet and Hecla, as more ore is probably raised by that company through a single shaft than by any others; but the Anaconda Company may in future take the lead in this respect.

The activity of copper production in the United States depends less on the output of any single mine than on the aggregate of the whole; for of the Spanish mines, Rio Tinto breaks and sells over 1,500,000 tons, and

at Manfeld in Germany, though only some 600,000 tons of ore are selected for smelting, to obtain this about 2,500,000 tons are mined, a quantity far in excess of that actually broken down by any single concern in the United States.

But it is in the smelting plants of the Western companies, and in the Eastern refineries where the most radical departures from precedent and older methods has been made. When reverberatories are used for either smelting or refinting, their size has been increased, till a matting furnace will smelt (per day) 50 tons of ore of average fusibility, and a refinery will melt a charge of even 100,000 lbs. Tilting matting-furnaces are sometimes used, and to ladle speedily the large charges of refined copper, ladles, either suspended from above or balanced on cars and holding from 250 lbs. to 500 lbs., are employed. Where cupolas are used, the smaller sizes have been everywhere abandoned in favour of furnaces which will smelt from 200 to 300 tons daily, and Bessemerizing has become almost universal for converting matte into 99 per cent. copper. No converters of less than 5 tons capacity charge are anywhere employed, and some of 15 ton capacity are used. Where the plan of the work permits, the copper is run, still molten, from the melting furnace to the converter, and thus re-melting and handling is avoided. By thus increasing the size of the furnaces and adopting the pneumatic method, large quantities of ore are manipulated in comparatively small works with a minimum expenditure of manual labour, and the work is well done. Of the total of 212,203 tons made in the United States, about 120,000 tons is refined in the United States by electrolysis, with the recovery, it is estimated, of about 14,000,000 ounces of silver, and about 1,400,000 dollars worth of gold. And yet Lake copper is not treated for gold and silver, but sooner or later it will be, and then another large item will be added to the credit side of the by-product account of the precious metals.

IRON.

At the same time that the copper mines of the United States were acquiring a preponderating influence in the copper market, her iron mining and her iron and steel manufacturing have been growing, till they have assumed proportions which are likely to render them one of the greatest powers in the industrial world.

This Society has always taken an interest in the progress of the iron and steel industry of

America: for in 1762 it awarded its gold medal "to the Rev. Jared Elliot, of New England, for producing malleable iron from the American black sand." This grandson of the famous "Apostle to the Indians" is recorded to have made a bar weighing 50 lbs. of metallic iron from 83 lbs. of black sand in a bloomery forge (Swank's "Iron in all Ages," p. 137).

It will help us in order more justly to judge of the growth of the iron industry of the United States during the past sixty years, as well as of the causes which stimulated it, if we adopt as a point of comparison an intermediate period—say the year 1870, that of the tenth census, when the impetus given by the Civil War and the effect of the high tariff, which was imposed as one of its consequences, were fully operative.

In 1840, the nearest census year to 1837, the total yield of the United States was 287,993 tons of cast iron, which was made in 804 furnaces, or 357 tons to a furnace, and 197,233 tons of bar iron turned out from 795 bloomery forges and rolling mills. Every seaboard state from Maine to Alabama contributed its quota. Even Ohio, Indiana, Illinois, Missouri, Wisconsin, and Michigan, though in the very infancy of their existence and before some were actually born into political life, appear in the list of producers; for the more remote the early settlers were from the centres of industry, and the more imperfect the means of transportation, the more necessary it was that they should supply themselves with that most essential article for domestic and agricultural use—iron. Almost everywhere the settler could find some iron ore, everywhere wood for charcoal, and a running stream with which to produce a water-blast and to work his trip hammer. In some of the more remote districts of the Southern States these, primitive furnaces and forges have survived until very recently.

Up to 1840, pig iron, with the exception of some experimental runs on anthracite and coke, was made exclusively with charcoal. But much of the cast iron from Western Pennsylvania, and even from the Juniata Valley, was taken to Pittsburg, which, on account of its cheap coal and geographical situation, had already become the most active seat of the iron and steel manufacturing trades. In 1837 there were already in Pittsburg 9 rolling mills and 18 foundries and machine shops. But though Western Pennsylvania was the largest producer of finished iron, Eastern Pennsylvania was the largest producer of ore and pig, and the centre of the iron trade was east of the Alleghanies.

If we look forward to 1870 we find the centre of largest production to have shifted westward, though it was still east from the Alleghanies, owing to Eastern Pennsylvania's large output. Pittsburg, already prominent in 1837 as a manufacturing centre, has become the undisputed Sheffield of America, not through the possession of iron ores, but because of its position at the junction of the Ohio and Monongahela, in the heart of a great coking coalfield. But she could have become the largest iron and steel manufacturer only because great iron deposits had been discovered west of the Alleghanies and on Lake Superior, and by the low steamboat and railroad rates which had been established.

Iron ores had been mined and smelted in Michigan before 1840, but the first ore shipped from the Marquette district, within 13 miles of Lake Superior, was in 1853. By 1870 Michigan iron ore production had reached 690,393 tons. Two other large deposits, the Pilot Knob and Iron Mountain, though long known and feebly worked, had been opened extensively in Missouri. These gave the predominance to the States west of the Alleghanies, notwithstanding that attention had meanwhile been attracted to the pure Bessemer ores of Virginia, and that the large deposits of magnetite on Lake Champlain were being actively worked. New York and New Jersey—though never very large producers—were, at prices prevailing then, important iron States. But the Bessemer process had been introduced, and pure iron ores were in such demand as to militate against the prosperity of certain mines producing an ore too high in phosphorus. Three years afterwards commenced a long period of financial depression, which, however, affected the iron trade only towards the year 1875. Thenceforward, till about 1879, iron manufacturing was well-nigh moribund, but it revived with an energy which has carried it forward without serious check to its rate of progress till to-day. When the revival occurred steel had almost supplanted iron, and the Bessemer converter, with its mechanical appliances and its possibilities of automatic operation, had replaced the old puddling furnace, and checked all attempts to improve Dank's or any other mechanical puddler. The Bessemer process and plant are supremely congenial to the American instinct, and as they can be made to fit into the working of the blast furnace so as to effect a continuous mechanical operation, it is not to be wondered at if both blast furnace practice and Bessemer practice

have kept pace one with another, with the result that blast furnaces, with a capacity of 700 tons of pig daily, feed fifteen ton converters, whose product is passed directly to the rolls. The whole aim and object of the American metallurgist, and this is especially true of the ironmaster, is to replace hand-labour by machinery, to secure the maximum of automaticity in every operation and series of operations, and to work his machinery to the maximum limit of safety. No two metallurgical appliances can offer freer scope to the exercise of his ingenuity and energy than the blast furnace and the converter, and the feats he has accomplished with these are demonstrated not only in the quantity he treats but in the low figure with which he can turn out the finished product, if we are to accept the prices at which American rails have been selling during the past eight months as indicative of their cost of manufacture.

Fortunately the discovery of new sources of ore have supplied him with the raw material to work upon. In 1870 the total production of ore was 3,395,718 tons of 2,000 lbs. each, of which 62 per cent. came from States east of the Alleghanies, the balance from western sources. The next great development in the industry occurred in the South where early in the eighties the iron ores of Alabama and Tennessee were actively exploited. These occur in juxtaposition with coal and limestone, and repeat in America the conditions prevailing in some of the British districts, with the one cardinal disadvantage however of distance from navigation. Cheap labour and cheap fuel and cheap ore have enabled pig iron however to be made in Alabama at figures never heretofore approached in America. But the ore being highly phosphoretted could not be converted into steel on an acid lining, and until recently the basic process has made very slow progress in the United States.

But meanwhile fresh discoveries of rich ore, some of them Bessemer ores, were made with startling rapidity on the shores of Lake Superior. In 1870 the Lake ores came exclusively from the marquette region of Michigan, but in 1877 the ores of the Menominee range of mines appeared in the market. The Gogebic range, situated partly in Wisconsin and the Vermilion range in Minnesota were found in 1884 to contain large ore deposits, and their development was followed in 1892 by the discovery of ore in the Mesabi range of Minnesota. With such rapidity have these immense deposits

been opened, and means of transportation by rail and water provided, that already they supply Chicago, Cleveland, Pittsburg, and other minor consumers with over 10,000,000 of tons annually, or two-thirds of the total United States production of last year, which was 15,957,614 tons. The Lake Superior mines have put into the market altogether about 100,000,000 tons of rich ore averaging 62 per cent., of which about 40 per cent. were Bessemer ores and 60 per cent. non-Bessemer. With such ores near navigable water, and with coal and coke cheaper at both Pittsburg and Chicago than it can be put on the cars in any coalfield of Europe, the large furnaces and rolling mills of the United States will enter, as dangerous competitors, the markets of the world, and be able to bid successfully, especially on rails and structural iron contracts. The most productive of all the lake regions are those of Minnesota. From the Vermilion range, the Minnesota Mine shipped in 1896, 448,757 tons, and the Chandler, 471,545 tons. The Mesabi range mines shipped from open-cut work, 1,500,000 of tons, and from underground, 1,000,000. The rate at which these soft surface or open-cut ores can be mined is indicated by the figure as the highest record of daily production from the Mountain Iron Mine, namely 4,446 tons, in ten hours, of ore removed by the steam shovel, after being loosened by blasting.

In the Rocky Mountains States and Territories there are large bodies of iron ore, but none have been exploited to any extent except in Colorado, where the steel works of the Colorado Coal and Iron Company are doing an increasing business. Elsewhere the population is too limited and the local demand too small to sustain iron furnaces and rolling mills.

It would be extraneous to my subject to more than refer to the extent and energetic development of the coalfields of the United States. Yet were it not for the wide distribution and favourable strategraphical position of her coal beds, the United States could not have taken such advantage of her iron ore resources as she has. The one industry has kept pace with the other, for there were mined of coal, and made as pig in the years:—

	Tons of Coal.	Tons of Pig.
1840 ..	10,000,000	286,903
1870 ..	33,003,315	1,865,000
1890 ..	156,013,611	9,202,703

The distribution of both is also widespread ;

for whereas iron ores are mined in large quantities from 19 States, coal is produced by 29 States.

It may not be uninteresting to compare the relative progress of the iron industry of the United States and of this country, as expressed by tonnage of pig produced at the three periods we have been briefly reviewing, namely, 1840, 1870, and 1890.

	England. Ton of 2,240 lbs.	United States. Ton of 2,240 lbs.
1840 ..	1,396,400	256,100
1870 ..	5,963,515	1,667,000
1890 ..	7,904,214	9,202,703

CANADA

IRON.

It is only a step, some twenty miles, from the western end of the Vermilion range of ore bodies to the Canadian frontier, and the rocks which carry the Mesabi and Vermilion ores cross that arbitrary line. It must not be taken for granted that the ore bodies themselves necessarily follow the rocks, for the exact limits within which ore might presumably be found was pointed out by the Minnesota geological survey before even the discovery of the Vermilion range mines. There is, however, a fair prospect of the discovery of similar bodies in Canada. Whether, if discovered, they would inaugurate a great iron industry in the Dominion, in the absence of coal and of a large domestic market, is doubtful; but were they discovered, with the enlargement of the existing canals, or the building of wider and deeper ones, such ores would be profitably imported into this country.

The only Canadian iron works of any great importance running 60 years ago were those furnaces, with such an interesting history dating back from French Colonial days, on the St. Maurice River in the Province of Quebec. They or their successors have always run on bog ores brought now by water from a considerable distance up the St. Maurice River. Their successors, the Canadian Iron Furnace Company, are running the Radnor Forges more actively than ever, and producing some 5,600 tons of pig annually. The ore being high in phosphorus has special value for the manufacture of car wheels. As in the early days of United States settlement, so in Canada a number of small blast furnaces and forges were erected in different sections of what is now included in the Dominion. These small establishments made iron castings and even some bar-iron for local use. Prior to 1837 there are records

IRON ORE PRODUCTION.

The following Table, compiled from the United States Census Report, the Mineral Resources of the United States, and Rothwell's Mineral Industry, shows with what rapidity important iron districts have been almost obliterated as others more prolific or better situated have come into existence :—

	1860.	1870.	1880.	1890.	1895.	
Alabama	—	—	171,139	1,897,815	2,199,390	
Colorado	—	—	—	114,275	240,937	
Connecticut	20,700	30,061	92,549	26,058	39,142	* Except as flux for lead and copper smelters, little or no iron ore is mined west of the Missouri.
Maine	—			2,500	—	
Mass.	30,000	3,700	127,101	32,934	—	† The figures for 1860 are palpably incomplete. The Amer. Iron and Steel Assoc. (Swank, p. 376) gives the production of pig iron for 1860 at 919,770 short tons. After enumerating the sources from which the 908,300 tons were mined in the U.S., the census table adds 2,309,975 tons under the ambiguous heading "Number of tons used in Furnaces," without specifying whence they came.
Delaware	—			35,657	981	
Maryland	2,300	98,354	84,583	244,088	272,014	‡ For 1870 the Amer. Iron and Steel Assoc. gives the pig iron production at 1,865,000 tons. The census return of 3,395,718 tons of ore is too small, as the Eastern iron mines never yielded as rich ore as the Western mines now do. The compiler of the census recognising the discrepancy, suggested that 800,000 or 900,000 tons be added to his total.
Georgia	—	4,500		22,873	—	
North Carolina.....	—	—	57,805	77,685	42,093	
Kentucky	—	—	1,948,334	7,141,656	5,812,444	
Michigan	130,000	690,393	—	891,910	3,866,453	
Minnesota	—	—	344,818	181,690	12,512	
Missouri	—	178,843	745,000	495,898	282,433	
New Jersey.....	164,900	362,636	—	81,632	47,026	
N. Mexico and W. Territories* }	—	—	—	—	—	
Utah	—	—	—	—	—	
New York	49,200	525,493	1,126,900	1,253,393	307,256	
Ohio	2,100	316,529	488,750	169,088	44,834	
Oregon	—	—	—	—	—	
Washington	—	—	—	—	—	
Pennsylvania	508,100	1,095,486	1,951,495	1,361,622	900,340	
Tennessee	—	34,619	93,272	465,695	519,796	
Texas	—	17,500	3,214	22,000	8,371	
Virginia	—	11,950	217,444	543,583	712,241	
West Virginia	—	—	—	25,116	—	
Wisconsin	—	2,000	37,000	948,965	649,351	
Indiana	—	—	—	—	—	
New Hampshire	1,000	—	—	—	—	
Vermont	—	5,000	—	—	—	
Total in tons of } 2,240 lbs. .. }	908,300†	3,395,718‡	7,489,464	16,036,043	15,937,614	
Omitted	2,309,975	900,000	8,048	—	—	
Corrected total	3,218,275	4,295,718	7,497,512	1,246,830	524,153	
Foreign ores im- } ported	—	—	—	—	—	

of nine such establishments, none of which survive to our own day except the Radnor Forges, and four only of which were running spasmodically at the end of the third decade (Bartlett, "The Manufacture, Consumption, and Production of Iron, Steel, and Coal in Canada;" and Bell's "Canadian Iron and Steel Manual for 1897"). There are in the Provinces of Quebec and Ontario in the azoic and paleozoic rock many deposits of iron, some of exceptional purity, from which considerable quantities of ore have been shipped to the

United States. Furnaces have also, since 1837, been erected at more than one place and time on the Ottawa and elsewhere, but commercial success has not rewarded their owners. At present there is a blast furnace in operation in Hamilton, Ontario, but it is fed by nearly three times as much ore purchased in the States as in Canada. There is no coal in Middle Canada. It must be brought either from the Maritime Provinces or across the Lake from the United States, and in that case pay a heavy duty. Canada might imitate Sweden and utilise her

purser ores by making a high-class steel with wood fuel; but to do so profitably would involve the creation of so many subordinate industries in connection with the iron and steel making that the undertaking would be onerous. Nevertheless therein probably lies her greatest likelihood of success.

Two interesting misadventures were made in iron manufacturing in Canada between 20 and 30 years ago worth remembering. One was the profitless attempt an English company made to make iron out of the *ilmenite*, containing about 50 per cent. titanic acid, which occurs magnificently situated on the banks of the St. Lawrence at Baie St. Paul below Quebec, and in very large quantities. Another was the courageous endeavour made by Mr. Mark Molson to utilise, in Catalan forges, the iron sands which have been concentrated by the waves into great banks of iron ore on the Moisie river, and at other points on the Gulf of St. Lawrence. By magnetic separation these sands can be freed from titanium, but their metallurgical treatment was attended with the same difficulties as beset the utilisation of those of New Zealand and of those of the Atlantic Coast which, as already stated, perplexed and was supposed to have been solved by the English colonists of Connecticut.

To-day Nova Scotia is the scene of most activity in the manufacture of iron. In 1849 iron works were established at Londonderry, in that province, which in 1873 were acquired by the Steel Company of Canada, and have now passed into the possession of the Londonderry Iron Company. The Steel Company, with a large capital, committed the initial error of commencing operations with a new process. That and other causes have determined its chequered career. It turned out in 1896 10,497 long tons of pig and 3,800 tons of wrought iron. One other is in active operation, the Nova Scotia Steel Company, which absorbed the New Glasgow Iron and Railway Company, incorporated in 1888, and the Nova Scotia Steel and Forge Company, which had commenced its operations in 1883. Its production amounted, in 1896, to 17,891 tons of pig-iron and about 75 tons of steel, which is manufactured into axles, &c. It is known as the Ferrona Company. It gets some of its ores from Newfoundland, where, on Bell Island, Conception Bay, flat deposits of iron ore, possibly of very large extent, are being opened. This ore is not phosphorus free, nor is it of very high grade in iron.

Nevertheless it is finding a market on the seaboard of the United States instead of in this country, although there it is subject to a heavy import duty. Parenthetically I may say that the mineral resources of Newfoundland, the oldest and most neglected of England's colonies, are worthy of receiving more attention than has hitherto been bestowed on them. Nova Scotia is the only locality, so far as is known, on the North American continent, where coal and good iron ore occur side by side on the very sea shore. It is true that the ore bodies are not of that enormous size which permits of a large output, but the favourable position in which they occur should ensure them success. Nevertheless the iron ores mined in Canada, according to the summary of the mineral production of Canada, issued by the Geological Survey, reached the insignificant sum of only 88,206 tons, in 1866. Of course, the production of the Newfoundland mines—the colony not yet having seen fit to throw in its lot with the Dominion—is not included in the above figure.

COPPER.

Copper is widely distributed throughout Canada, every section except the Prairie region having, since the fourth decade of our century, witnessed the expenditure of money in copper-mining, with, in some instances, a certain degree of success. In Newfoundland there have been exploited several sulphuretted ore mines, from which considerable quantities of ore and matte have been shipped within the past 30 years. The mines are all immediately on the sea shore. The interior of the island, though one section has just been traversed by a railroad, is practically unexplored. In Nova Scotia and New Brunswick, on the Bay of Fundy, and elsewhere, copper ore in mesozoic rocks has been found but not successfully worked. In the Province of Quebec the rocks of the Quebec group carry inter-stratified beds of copper ore of very great extent but of very low grade, and also lenticular masses of pyrites, which some twenty-five years ago tempted capital from this country. The same Capelton mines, abandoned by their British owners, to-day supply sulphur ores profitable to the United States acid and copper works. The old Bruce mines on the shore of Lake Superior, which were for a time a profitable investment under the management of John Taylor and Sons, have not been worked for about 25 years. But in the same rocks to the north-east, at Sudbury, have been worked for the past

12 years the most extensive copper deposits in Canada, and the most productive nickel mines of the world. As the copper is, however, combined with the nickel in the same ore, and as it is not rich in copper, its extraction is limited by the demand for its associated metal.

Another region more recently entered where copper is also a bye-product, is Southern British Columbia. As yet the quantity of copper exported thence in gold and silver matte has not been great, but if the Crow's Nest branch of the Canadian Pacific now under construction, as I have already remarked, can supply the Kootenay and Boundary Creek districts with cheap fuel, their production of copper will not be inconsiderable. Canada has made no zinc, and as yet what lead she has produced has come from British Columbia, and has been in great measure exported as ore to the United States.

Canada has never figured as a threatening factor in the silver market. Thirty years ago startling discoveries of native silver and pure silver ore were made on Silver Island, in Thunder Bay, Lake Superior. Large quantities were extracted very rapidly, but the deposit was of limited extent. Along the north shore of that Lake, on Pie Island, and in the adjacent districts west of Port Arthur, silver mines of considerable promise have been from time to time opened, but not with very profitable results. The lead and copper ores of British Columbia carry silver, and from that region a notable amount will undoubtedly find its way into circulation. But the total value of the metallic product of Canada in 1896, as will be seen from the following extract from the mineral statistics collected by the Geological Survey of Canada, amount to only 8,039,640 dols.

Product.	Quantity. ¹	Value. ¹
<i>Metallic.</i>		dols.
Copper (fine, in ore, &c.), lbs. ²	9,385,556	1,021,148
Gold, tons	—	2,810,206
Iron ore, tons.....	88,206	184,313
Lead (fine, in ore, &c.), lbs. ³	24,199,977	721,384
Nickel (fine, in ore, &c.), lbs. ⁴	3,500,000	1,155,000
Silver (fine, in ore, &c.), ozs. ⁵	3,205,343	2,174,579
Total metallic.....	—	8,039,640

¹ Quantity or value of product marketed. The ton used is that of 2,000 lbs.

² Copper contents of ore, matte, &c., at 10·88 cents per lb.

³ Lead contents of ores, &c., at 2·98 cents per lb.

⁴ Nickel contents of ore, matte, &c., at 33 cents per lb.

⁵ Silver contents of ore at 67 cents per oz.

Gold appears as the most valuable item.

Gold was discovered in the tributaries of the Chaudière river, Province of Quebec, sixty years ago; and, ever since, the gravels of several of the smaller rivers of the county of Beauce and the Upper Chaudière has yielded a small but constant stream of gold. Strange to say, though the gold is coarse and sometimes entangled in quartz, no profitable quartz vein has been opened.

Since 1860 Nova Scotia has appeared as a small but steady producer, having yielded altogether about 13,000,000 dols. from small but very rich veins. Thoroughly conclusive experiments have not been made in the treatment of the low-grade slates which enclose the veins, and which, if they should prove capable of profitable mining would raise Nova Scotia to a position of prominence among gold-producing countries—for the area over which gold is found and worked is extensive.

Gold is also widely distributed over the province of Ontario—from the extreme east in Madoc and Marmora countries to the extreme west, where to the west of Lake Superior, around Rainy Lake, Lake of the Woods, and Lake Shebandovau the yield is already considerable and the prospects most encouraging.

But at present, perhaps unfortunately, the merits of other districts are being obscured by the wonderful discoveries on the Yukon.

I have already referred, incidentally, in discussing the early gold discoveries of the United States, to the recent Alaskan finds. It would be unreasonable to suppose that every one of the thousands who flock thither will make a fortune; and of course in that arctic climate and those northern regions, the hardships which those who fail, and even those who succeed, will be subjected to will contrast most unfavourably with the lot of those who

flocked to California or Australia. But while to the west of the mountains in that remote region, both the climate and the physical conditions are in the highest degree unfavourable, life is much less intolerable in the Mackenzie country to the east of the range. The resources of that vast section of the Dominion are but little known. The superficial explorations, however, of the Geological Survey of Canada, concur with the reports brought thence by United States prospectors—and many of these restless, hardy explorers have penetrated it—in pronouncing it one of the richest mineral regions of the world. Coal and lead ores are said to crop out in great abundance, on the banks of the Mackenzie, and petroleum to well forth almost as in the Baku district. The rush, therefore, to Alaska may hasten the development of this vast territory.

When we look at the map of North America we find that the territory controlled by Great Britain exceeds that of the United States, with Alaska included. But of this immense area of over 3,600,000 square miles, only a very narrow fringe along the St. Lawrence, the great Lakes, and the United States frontier has even been explored. There are probably 150,000 square miles in the Peninsula of Labrador alone which have not even been trodden by the feet of white men. The rocks composing a very large proportion of this enormous area are those which in America and elsewhere carry the most valuable mineral deposits. Therefore, Canada's prospect of becoming some day or other a rich metal-producing country are bright in the extreme. Her progress, however, will necessarily be slow, not only on account of the severe climate, the impediments it throws in the way of individual prospecting, and the heavy timber and deep alluvium, which covers so large a proportion of her mineral-bearing rocks. But when we look at the extraordinary mineral wealth developed immediately south of the Canadian line, whether in the iron ores of Minnesota or the copper, gold, silver, and lead of Idaho and Montana, we cannot but foresee an extension of like wealth to the country north of that arbitrary line, when once the same energy is exerted and the same wealth is risked in the discovery and in the development of Canada's mineral resources. It is, however, hardly to the credit of Canadians or of Englishmen that to-day most of the mining, one may say almost all, is done by citizens of the United States with United States capital.

DISCUSSION.

Mr. BENEDICT KITTO said he had listened with extreme interest to this very able and clear paper, which must have made every one feel that it was time for England to think very seriously of her position as a metallurgical and mining country. He was not prepared to enter on any discussion of the facts and figures which had been given; but he must say that Professor Douglas had put before them food which would require a good deal of digestion.

Mr. W. SEMMONS said he met Professor Douglas in Arizona 14 years ago, when the district was producing a large amount of blue and green carbonate of copper. He knew that English smelters had derived a great deal of information and benefit from the remarkable manner in which the Americans had utilised their machinery, but there were certain points which had to be considered. In the first place there were no copper deposits in Europe, except the Rio Tinto, at all corresponding in size of those in the Western States of America, and there was not the same opportunity for utilising machinery on a large scale. Again, with regard to the iron deposits, he had been over the Marquette district, and was much struck by the ease with which the steam shovels were used in mining in the same way as they were employed on English railways. The facts brought forward with regard to the cost of iron in America as compared with Europe were somewhat alarming. When he entered the copper trade some 35 years ago England was the chief producer, or almost so in the world, but we were now almost at the bottom of the list, and it looked as if we intended to occupy the same position with regard to iron, and at any rate the prospect was very serious. The facts mentioned by Professor Douglas ought to be considered very seriously both by masters and men, for unless they could come together, he feared the trade of England would suffer such a collapse as would probably be irretrievable.

Mr. D. A. LOUIS agreed that the warnings conveyed in the paper ought to be taken to heart, but the point just mentioned was important. In fact, a neighbour of his, when he heard the remark that England ought to follow the American methods, suggested at once that they must first find the American deposits. To a large extent the same remark applied to the iron industry. America had much larger areas, and therefore much larger quantities to draw from. Anyone who followed the work of the Iron and Steel Institute would be aware that due attention was paid to any improvement that took place in the industry all over the world. Not only was information obtained from the members, but from workers in America, and in addition to that direct information, a considerable amount of indirect information was drawn from various journals, technical and otherwise, and if the matter were sufficiently important it

was duly noted in the Journal of the Institute. The members were men of considerable practical experience; they read all these communications, and if they found anything of sufficient importance, no doubt they would adopt it. On the whole, therefore, he did not know that the reproof which had been administered was altogether justified, because he thought these men, good men of business, would readily adopt any improvements they thought advisable. These methods were also put before the meetings of the Institute of Civil Engineers, Mr. Head having recently read a paper there on the most recent methods adopted in the United States. They were known to all iron masters, and he had no doubt that if they thought it necessary or expedient they would even go to the enormous expense which it would entail to alter their own plant. Some of the places referred to he had visited, for instance, those on the Gulf of California, some years ago. Up to the present they had not proved such dangerous rivals as it had been suggested, but, of course, they might be in the future.

Mr. F. A. ROBINSON, referring to the comparison made between the old-fashioned stamps and the modern ones, said they must go back a very long way to find one which only crushed one ton a day, and it was not quite a fair comparison unless it were stated what the steam stamp was contrasted with. With the ordinary method at present they crushed as much as 5 tons a day, per head. He should like to know if the comparison was made with a single stamp or a series of stamps, such as were usually used. As far as his knowledge of mining machinery extended, it appeared to him that the ordinary gravitation stamp had always proved the most economical and efficient, and it was adopted in almost all mining countries.

Mr. LOUIS said he had intended to refer to this point. At the Anaconda Mine he believed the output was 300 tons per head with the steam stamp, which was a very different thing from the ordinary gravitation stamp. He should like to ask the last speaker what sort of gravitation stamp it was which did five tons a day per head?

Mr. ROBINSON said there were any number in use now.

The CHAIRMAN said in listening to Professor Douglas, the thing which attracted his attention more than anything else, was the suggestion that the English were altogether behind the Americans in the application of machinery. He must say he could not at all agree with him there, because in the iron and steel industry, which Professor Douglas particularly referred to, all the important processes, with hardly a single exception, had been conceived and developed in England. This was a big thing to say, for the iron industry was by far the greatest metal-

lurgic industry in the world. It was quite true that the Americans had done a great deal in arranging machinery so as to economise time, labour, space, and so on, but all the main ideas—the backbone of the processes—had been developed in this country. One had only to go back a little to verify this statement. The puddling process was due to England, and so with the Bessemer process, the development of which by Sir Henry Bessemer was such a triumph of mechanical genius, and which had been very little improved on since, except in some points of detail, and in working out some of those points Americans had certainly had a share. For instance, Mr. Holley greatly improved the plant from the point of view of rapidity of repair, thus introducing considerable economy, reducing loss of time, and increasing the output. Then there was the Siemens process, the rival of the Bessemer, which and all the appliances connected with it, were in the main evolved in England. So with the basic Bessemer process, and with the system which enabled reheating to be done away with very largely, “the soaking-pits;” and so one might go on for a long time. Turning to copper, the very process which Professor Douglas laid special stress on, the converter process, was after all only the outcome of the Bessemer process, and that was not worked out in America but in France. No doubt in America they had had great advantages in times past, owing to the large quantity of ore available as compared to this country. This was only a little island, we had a certain amount of tin, but not much lead or copper, and if we had large iron smelting works, it was not entirely due to the presence of native ores, but in great measure to the facilities we possessed for importing suitable ores from Spain, Algeria, and elsewhere. He could not help thinking that in the future there would be a complete change of conditions. In Australia there were enormous deposits of complex lead ores—in the Broken Hill district, for instance. Up to the present they had been working surface ores there, which required only simple smelting processes; but now they had nearly got through them and were face to face with a very complicated problem—the treatment, economically, of the complex sulphide ores beneath, which were very rich in zinc, and troublesome to deal with. There were vast deposits which would enable us to gain experience which previously had been impossible, and the same thing was coming about in British Columbia. Very large deposits were being found there of lead ore containing a good deal of gold and some silver. The Waverley, the Tangier, the Hall, and other mines which had lately been opened up showed very large deposits indeed. There were also big deposits in Tasmania, at Mount Lyell and elsewhere, which would give good experience. He was therefore of opinion that before many years the engineers who dealt with these things would not be so much drawn from America as they had been recently, for the

simple reason that we had not had the material for these engineers to be educated on. With regard to competition in the matter of iron and steel, there was a point of considerable importance, viz., the tariff question. If America imposed a duty on ore it gave them a considerable advantage, and they could ship over here any excess amount of iron they produced, and sell it at a very low figure. That no doubt had been done, but there were a great many things to be taken into consideration. As Mr. Louis had pointed out, we had many engineers—Mr. Martin, Mr. Windsor Richards, Sir Lothian Bell, and others—who kept watch on everything going on in the world connected with iron and steel, and they were not the men to let slip any opportunity. The Dowlais works recently put up by Mr. Martin at Cardiff were a great advance on anything which had been seen before in the way of handling material, and he could hardly agree that we were behind America. We had to deal with matters from a very different standpoint. He was in America with the Iron and Steel Institute in 1890, and went all through the iron works at that time with those competent to judge of the question, and he could speak from experience as to the way they considered every point that presented itself to them. He would conclude by proposing a hearty vote of thanks to Professor Douglas.

The vote of thanks having been carried unanimously,

Prof. DOUGLAS, in reply, said in early days the old up and down stamp, with a wooden stem, was used—not the Californian rotating stamp—and that would not crush more than one ton per stamp-head. To-day the enormous steam stamps crushed 250 tons of Lake ore, which was extremely hard. They could crush as much as 350 tons at Anaconda, but of that large amount of stuff nearly one-third was screened out before it went to the stamps. About 250 tons nett was really crushed. You could not handle 6,000 tons a day if you only crush one ton per stamp-head. It would mean 6,000 stamp-heads, which would nearly cover a county. With regard to the Chairman's animadversions—to a certain extent he thought when he came to read the paper he would find that he emphatically disclaimed the idea that any process originated in America. He should say that he was not an American but an Englishman, though he had lived 20 years in the United States. But he could recognise that circumstances had imposed on Americans conditions which they had been obliged to follow, and he thought other people would be equally obliged to follow them. He quite agreed that all the science came from this side, but they took up processes such as the Bessemer and worked them to the very limit of the power of endurance of machinery and of human life. The same with the blast furnaces and with everything else. It might be a great mistake, in

some respects it was a great mistake, but they did it, and what was the result? They did not throw their waste material on the European market, but rails were sold, before the decline in price, in the United States at 5 dols. or 6 dols. a ton less than they could be bought in any part of Great Britain. He admitted that the steel trust broke down; at the same time they had been selling billets at 15 dols., and 3 dols. was enough to turn billets into rails by automatic machinery. They took the processes which were devised here, and used them by the aid of automatic machinery, so as to minimise the employment of human labour. The conditions of the day made it impossible for the English metallurgist to do the same without terrible friction with his workmen, and without cutting loose from all those sympathetic ties which bound master and man together in many districts of Great Britain. From that impediment they on the other side were freer. There, there is probably consideration for the workman. The workman was, in a sense, a tramp—he came and went; he had no local habitation in the place; his father and grandfather had not lived there before him; he came and went as he was employed or thrown out of employment. One of the largest ironmakers in the States had been able to discharge 500 workmen by the introduction of electric cranes. Shortly after that he went through several ironworks here where there were hundreds of little engines, each one working a crane. In the big American works there was an electric establishment which generated enough power to run all the cranes, and one man ran the engine which worked the dynamo, and so an enormous number of men attending to all the little engines and furnaces were dispensed with. That was a waste that must be remedied here. He did not question the credit done Sir Henry Bessemer or anyone else who devised the methods which American metallurgists were using. In any works on this side the Atlantic the utmost consideration was shown to the workmen. He had been at Mr. Krupp's works at Essenden. There he found the Bessemer converters out of blast, and when he asked what was done with the men he was informed that Mr. Krupp had put the men at work making another colony. He said it appeared to him that a man who was an adept in working a Bessemer converter would not be the best men for building a colony, but the reply was that Mr. Krupp would never discharge a workman if he could find some other work for him to do. How the friction between employer and employed and how sympathetic and social questions were to be got over was a very grave question, but they had to be met somehow. As yet, on the other side, any trouble from the discharging of men had not arisen, because they had been able to go on increasing production at a greater rate than they had been obliged to discharge the men. But they would some day or other reach the point when that increment could not go on, and then would come friction. But he felt sure that, to a great extent, the processes

invented and employed here could be used in the same way as they were used on the other side. The result would be a cheapening of production—an expansion of the market and the employment of more instead of fewer men. It was no doubt difficult for a workman to see this; but this is certain—if he impedes the adoption of machinery and its freest use, he will so handicap British industrial progress as to enable all Britain's competitors to beat her in the race.

Miscellaneous.

FLETTON BRICK INDUSTRY.

The following particulars respecting the manufacture of bricks in the neighbourhood of Peterborough are taken from an article in *The Builder*:—

Travelling from London to Peterborough by the Great Northern Railway, just before arriving at the latter station the line passes through an area which is covered with brickworks, the tall chimneys of which cannot fail to attract the attention of any traveller.

The district south of Peterborough, through which the railway runs, and which is called "Fletton" or "Old Fletton" (hence the name of the bricks), has an underlying bed of clay many feet in depth; at a very small distance below the surface is the top bed, which varies from 6 ft. to 10 ft. in depth. This top bed is the plastic clay, and its under surface approximates to the horizontal: the varying contour of the ground gives the difference in thickness. Underlying this is the lower bed of shale or "knots," as it is locally termed, from which all the pressed bricks are made. This bed varies from 25 ft. to 40 ft. in depth, and is quite clean and free from sand, stones, or other matter which would injuriously affect the manufacture. Below this bed there is a layer of clay mixed in a greater or less proportion with small boulders, shells, and other *débris* of a like nature. As all the lime, stones, or shells have to be picked out of it for the good bricks, this lower bed has not been much used as yet. Below this it is understood there is another bed of good "knots."

However, it is with the main bed of knots that the brickmaker of the present time deals, and in this manner:—The men "bar the stuff down," that is, with a long crowbar work vertical holes in the clay, in ledges, all down the face of the pit, knocking the detached portions into small trucks, which are placed close to the face at the bottom. These trucks are run on tramway lines, and are connected with suitable winding gear, by means of which each truck is hauled up into the grinding-shed, which is usually on the first floor of the works, the presses being underneath. The grinding shed has in it one or more grinding

pan, a machine something like a large mortar mill, having the outer portion of the bottom perforated. The clay is tipped from the truck into or near the grinding pan which is fed by a man, and as the clay is turned from large lumps into small, about the size of coarse oatmeal, it falls through the perforated portion of the pan on to the floor; thence it is distributed by elevators, &c., to the various parts of the floor required to serve the presses below, the holes in the floor being connected with the presses, which are directly underneath, by means of coarse canvas chutes. The presses are arranged on each side of a long building, if there are many; and, of course, in front of one side of this building should be the kiln, or kilns—or on both sides, if the works be large—as the bricks must be wheeled from the presses to the kiln, and the less the amount of manual labour the cheaper the output. The press has a hole in the iron table the size of a brick, with a bottom working up and down, and also a ram with a square head worked by an eccentric motion; the bottom is depressed, the square cavity filled with powdered clay (just sticky enough to adhere together when pressed tightly between the fingers), the square head comes down, presses the clay, and rises; at the same time, the bottom rises, pushes the brick forward on the table, from which it is lifted by a boy and placed on the barrow, ready to be wheeled to the kiln, square, hard, with clean arrises, and fairly dry. Herein lies the secret as to how these bricks can be turned out at such a rapid rate and moderate cost; it is not ten minutes from the time the clay is "barred down" until it is in the kiln, if there is not a great accumulation of clay ready ground. No time is wasted in drying the bricks on the hacks, as is usual with the plastic clay, and, of course, the long process of weathering and tempering which is in use in the preparation of many of the brick earths is not required.

Many of the old Scotch or Dutch kilns are to be seen about the works at Fletton, but they are being superseded by some form of kiln similar to "Hoffmann's," the general arrangement being a large oblong building in several compartments, eighteen being a common number; these compartments are arched over, and communicate by means of flues with a chimney shaft. Each compartment has a doorway or opening at the ground level large enough to wheel the barrow in, the bricks are stacked up to the top, leaving spaces between each, and when the compartment is full the doorway is roughly bricked up and plastered over with clay, except a small opening at the bottom of the doorway or wicket, at which a small fire is made to help to dry and heat the bricks before the regular firing is commenced, when this hole is stopped up; then the fire is fed with small coal from a hole in the top or roof, about 4 in. in diameter, the amount of fuel used being, for these bricks, about 1 to 1½ cwt. of coal per 1,000 bricks burned. With a kiln of eighteen compartments, one can be filled each day and one drawn, the intermediate compartments

being in the various stages of heating, burning, and cooling down.

It seems probable that the shale or "knots" possess some natural oil or gas which assists in the burning operation; this may be equivalent to the coal or cinders mixed with the clay in the case of stock bricks, as the amount of coal used appears very small.

The above is a general description of the methods adopted when dealing with the bed of shale or knots, and the bricks from it may be known by having some description of frog.

The top bed on plastic clay is ground, but in a plastic state, not dry as in the case of the knots, water being added to bring it to the proper consistency, to allow of its being forced out of the orifice at the end of the machine in a stick or band the size of a brick on edge, about 9 in. by $4\frac{1}{2}$ in. This stick or band is cut into sections by means of wires arranged in a frame, each section being a brick without any frog, and may be distinguished by the marks of the wires on each bedding face. The bricks are then dried on the hacks or in a drying-shed, or may be pressed in a machine, which gives them a better face, and also forms a frog. It is from this top bed, by the plastic process, that the white Fletton bricks are made.

The bricks, when well made, are good, being particularly well formed and hard; they have a clear ring when struck together, and are dense and compact when broken across. At the same time it is evident that unless care is taken in the manufacture they will not possess these qualities; if the shale is too dry, or if the supply to the machine be insufficient, or the pressure not enough, a poor brick with the particles not adhering to each other will be the result, having neither strength nor power to withstand the weather, particularly frost; and it appears that it would be to the advantage of the manufacturers if they took pains to turn out first-class goods, as there is no doubt that opinions vary as to the weathering qualities of the bricks, particularly as to the effect of frost combined with damp upon them. The outer skin of all machine-made bricks coming in contact with the oil or grease used in the machine no doubt helps to make a fine surface, but probably does not improve the weathering qualities. An object-lesson in this respect may be seen in some portions of the brick facing of St. Pancras Station, where the coal wharfs are, parts of the original face of the bricks having entirely disappeared within the comparatively few years the station has been built.

As regards the strength of Fletton bricks, some accurate information is given in the second report of the brickwork tests carried out by the Science Committee of the Royal Institute of British Architects, published in December last. On page 100 of the report it is stated that Professor Unwin tested two samples of Fletton bricks, one marked "Plowman," the other without a mark, the crushing load of the first being equal to 202.7 tons per square foot, and of the second, 239.0 tons per square foot. This stress is slightly higher than that given in the first report for

Gault bricks, and lower than that of Leicester red bricks from Elliston. It seems important for the architect, engineer, and builder in general, to bear in mind that single bricks, the crushing load of which will reach, say, 210 tons, will only carry from 20 to 30 tons before crushing when built in piers, or approximately only one-eighth of the load carried by the single brick, the actual figures being below this for work in mortar and above it for work in cement.

TREATMENT OF VANILLA BY CHLORIDE OF CALCIUM.

There is hardly a sugar estate in the island of Réunion, which has not more or less land under vanilla, varying naturally in extent, according to the nature of the locality. On the other hand, in certain districts are to be found large planters who cultivate nothing but vanilla, and as regards the quarters of St. Rose, St. Philippe, and St. Joseph, it is no exaggeration to say that the mainstay of the people is vanilla. The yards and courts, and little plots of ground round the huts are covered with the vanilla creepers. When the pods are ripe, they are sold green to a neighbouring merchant, realising quite a little fortune for the grower. In a report recently issued on the trade and industry of Réunion, Consul Bennett has devoted attention to the question of the treatment of vanilla by chloride of calcium, and the whole system of preparing the vanilla bean in the island. The object aimed at in the treatment of vanilla is to endow it with keeping properties, and at the same time develop the perfume which has not yet come into being at the moment of cropping. Pods of the best quality should be perfectly smooth, and without excrescence or holes. The longer the pods, and the more perfumed they are without acidity, the more valuable is the vanilla. The success of the treatment of vanilla depends upon the care bestowed upon it, and especially upon the state of maturity of the pods. If the vanilla is picked too green, its treatment will be difficult, and its keeping qualities doubtful; the pods will be thin and poor after drying, whilst the perfume will not be properly brought out, and what there is will be lacking in quality. If plucked when too ripe, the treatment will be easy, the pod will be of good size and highly perfumed, but it will split, and thus the vanilla will lose much of its commercial value. On a well-ventilated and properly exposed plantation, the pods are ripe when the lower part begins to turn yellow.

The treatment by chloride of calcium consists of several operations. These are:—(1) Stoppage of vegetation; (2) first drying and colouring; (3) further drying; and (4) watching. The process of drying in a stove by means of hot water is the one resorted to. On the day of the cropping, or the next day at latest, the pods are put to dry by heat in tin cases.

Old petroleum oil tins are generally used for the purpose; the size may be slightly altered, but the width and breadth of the box should not be too large, as the vanilla in the centre should be subjected to the same heat as that which is nearest to the sides of the box, otherwise the treatment of the pods in the centre would not be assimilated to that of those at the sides, and the resultant colouring would be slightly different. These boxes are fitted with lids closing on the outside of the box; they are lined with wool carefully arranged along the bottom and up the sides, and a little over the tops of the sides. The vanilla pods are placed on end, close enough to secure pressure without damage by rubbing, a horizontal layer is placed on top of these, the wollen cover is folded over all, and the lid put on. The boxes thus arranged, are put into the halves of wine barrels, and hot water emptied into the barrels up to the lids of the boxes, care being taken that no water gets into the boxes. In order to prevent the sudden cooling of the hot water, the barrel is covered with a piece of sacking. It is left thus covered during one night. Next morning the pods are withdrawn and exposed in the air for some time to dry; then for two or three days they are kept under woollen coverings in full sunlight. For this operation low wooden boxes are used, a single layer of pods being placed in the bottom and covered with a woollen cloth. The boxes are placed in sunlight on trestles, to prevent contact with the more or less moist earth. After this operation the colouring of all the pods will be uniform, if the drying by hot water has been properly done. Now is the moment to proceed to the drying operation.

The old methods of preparation—drying in the open air upon screens, in an airy situation, or in hot-air stoves, in which the heat is constantly renewed—result in a loss of perfume, and at the same time require a large amount of hand labour. These drawbacks are avoided by drying in closed vessels by means of chloride of calcium. This operation is carried on in boxes of galvanized iron with an hinged door, and closing on an indiarubber edging to ensure air-tightness. Each box has eleven drawers or trays; the bottom and the sixth drawer are for the vessels containing chloride of calcium, the others are for holding the vanilla. In the former are placed 18 kilogrammes (about 40 lbs. avoirdupois) of chloride of calcium, and in the latter 45 kilogrammes (99 lbs.) of vanilla. The vanilla is laid upon wooden hurdle-shaped frames resting upon little brackets rivetted into the sides of the box. The tray can thus be drawn out in order to arrange the vanilla properly; several layers are placed on each tray. The trays should not be made of resinous or strong-smelling woods, as vanilla absorbs and retains odours it comes in contact with. The vessels containing chloride of calcium should be double-bottomed, the inner one being perforated to allow of the escape of the liquid chloride of calcium. Each time the case is opened the chloride vessels are looked to, and the chloride renewed or added to as necessary. When the trays are filled with vanilla, and the chloride vessels

are in their places, the door is closed, and to make sure that the boxes are hermetically closed, all rivets in the box are soldered beforehand. Every two or three days the vanilla is carefully examined, and any pods showing moisture are taken out and put aside to be placed in the sun and prepared by themselves in a special box where they are all collected. In from 25 to 30 days the vanilla will have reached the required degree of dryness. Practice will show the exact moment when they should be withdrawn. Vanilla insufficiently dried will not keep and breeds small worms; vanilla over-dried keeps well, but it is not supple, it is called "broken," and has less commercial value. After leaving the box, the vanilla is placed for several days on small frames, in a covered and well ventilated place, then it is removed and shut up in tin boxes, each holding from 15 to 20 kilogrammes (33 to 44 lbs.) of vanilla. There it remains for several weeks, being examined every two or three days, and if any of it shows traces of mildew it is carefully wiped. When it is thought that the vanilla has reached perfection (*rendue à point*), and its perfume well developed, the cleaning of the vanilla is taken in hand in order to remove the dust, and the germs of mildew which may adhere to it. Vanilla which is not subjected to this process is dull in colour and does not keep well. Water to the amount of about six gallons, at about 140 deg. Fahrenheit, is emptied into a perfectly clean receptacle, and 44 lbs. of vanilla are thrown into it, and vigorously stirred up in the water by hand. The pods are withdrawn, lightly wiped, and put to dry in the shade. In a few days when the pods are dry, they are sorted and classed according to length and quality, and made up in bundles. All these operations must be conducted with the greatest care. The bundles are placed in tin boxes with covers. Each box contains only vanilla of the same length and quality, and holds from 4 to 5 kilogrammes each (9 to 11 lbs.). Vanilla is never sent away immediately after treatment. It is watched for at least a month to make quite sure that it will keep good during a sea voyage. During the time it is being watched, the boxes are examined twice a week, and every pod showing the least sign of moisture is withdrawn. The mildewed pods are worked up by various processes, and sold as inferior vanilla.

Obituary.

SIR HENRY DOULTON.—Sir Henry Doulton, who had been in failing health for some time, died on the evening of Wednesday, the 17th instant. He was born in 1820, in Vauxhall, where five years before his father, in conjunction with Mr. Watts, had established the pottery which afterwards developed into the great manufactory at Lambeth which has made

the name of Doulton so celebrated. Though intended by his parents for one of the learned professions, and having received a good education at University College School, he preferred to devote himself to the factory, and in later years of his life he was often fond of referring to his early skill at the potter's wheel. He became an accomplished "thrower," and much of the largest work which was in those early days turned out by the works was done by him. The factory was a small one with a small staff, and he has stated that it was no uncommon occurrence for him to obtain the order for some goods, make them, deliver them, and receive the money for them.

In 1846 he commenced the manufacture of stoneware drain pipes. In spite of opposition and of difficulties of manufacture, he succeeded in introducing these largely—so largely indeed that an additional special factory had to be erected in Lambeth, and a few years later additional works in the provinces. The firm also obtained a reputation for large stoneware vessels and appliances intended for chemical and other similar uses, the excellence of which was proved by the award of medals and favourable reference in the jury reports of the exhibitions of 1851 and 1862. For many years the productions of the firm were almost exclusively of a utilitarian nature; but among the articles they made were such things as ale pots and mugs of stoneware of both traditional and original design, while they also manufactured terra cotta vases in red and buff clay. In the early sixties, however, Mr. Doulton and his colleague were endeavouring to produce stoneware articles of higher artistic merit, and at the Paris Exhibition of 1867 Messrs. Doulton showed, amongst their pipes and chemical ware, some ornamented jugs and vases. The efforts of the firm in this direction received great assistance from the then recently established Lambeth Art School, of which Mr. Sparkes was the master, and the result of their combined efforts was seen in a case of very beautiful ware shown at the International Exhibition of 1871 at South Kensington. Up to that date almost the only decorated stoneware had been the old "Grès de Flandres" jars and flagons or "greybeards," and the "Bellarmine," made originally in the Rhenish provinces, and afterwards at Lambeth by Dutch or English potters, and the new Doulton ware was really a revival of this old salt-glazed stoneware. The appreciation with which the new pottery was received, encouraged the manufacturers to persevere, and at the Vienna Exhibition of 1873, Messrs. Doulton and Company were able to show a magnificent collection of the ware now well-known under the name of the firm. They were thus encouraged to devote themselves seriously to the production of artistic pottery of the very highest class, both decorated stoneware and the under-glaze painted earthenware known as "Lambeth Faience." Before long a second branch of the factory was established which rivalled in commercial importance the original

stoneware factory, and obtained for the firm a reputation which they could never have achieved in its purely technical line of business, important as it became. How great was its industrial development may be judged from the fact that an establishment which in 1834 consisted of 12 persons, working up 6 tons of clay a week, now—at its various branches—uses some 2,000 tons of clay a week and gives employment to 4,000 persons. The original works also at Lambeth have been supplemented by branch establishments at Rowley Regis, Smethwick, Burslem, St. Helens, Paisley, and Paris.

One of the results of the establishment of the art pottery at Lambeth, and a result of which Sir Henry Doulton was justifiably proud, was the opening it afforded for the employment of considerable numbers of educated women, since among the 4,000 employees of the firm there are now some 400 artists, all engaged on the work of design.

The services which Henry Doulton, as the guiding spirit of his great firm, rendered to the development of the potter's art in this country, were fitly recognised by the award of the Albert Medal in 1885, "in recognition of the impulse given by him to the production of artistic pottery in this country." Another personal distinction which he received was his knighthood in 1887.

Sir Henry Doulton was one of the oldest members of the Society of Arts, which he joined as far back as 1851. He was a Member of the Council from 1877 to 1880, 1882–1883, and 1886–1889, and a Vice-President from 1890 to 1894. On several occasions he took the chair at the meetings of the Society, and frequently took part in the discussions.

Correspondence.

THE LIFE WORK OF THE LATE SIR HENRY DOULTON.

May I be permitted to add to the obituary notice of the late Sir Henry Doulton in this week's *Journal*, some supplementary remarks on the great and, in every sense, beneficent impulse given by his personal enthusiasm and public spirit to the production of cheap art pottery in this country, by the revival in Lambeth, since 1871, of the manufacture of ornamental salt-glazed stoneware, of the kind which has become popularly known as "Doulton-ware," and, since 1873, of under-glaze-painted earthenware, or, as it is now distinctively called "Lambeth Faience."

The origin of the potteries at Lambeth can be traced back to the 17th century, when some Dutch immigrants settled in the parish, and made it, what it has ever since remained, the *vicus ceramicus*, or "potters' quarter," *par excellence*, of London. They carried on their art there after the manner in which they had carried it on for generations before in

Holland, and so firmly rooted it, both in Lambeth and Fulham, and, also, though their success in these places, among the ancient tilewrights of Staffordshire that, within 100 years, the English manufacture of "Delft," or enamelled earthenware had almost entirely extinguished that of Holland itself. Thus Macpherson, in his inexhaustible "Annals of Commerce," writes, in 1765:—"Formerly we all took our meat off plates made at Delft, in Holland; now the Dutch generally use our Staffordshire ware."

Lambeth was indeed made altogether Dutch, and almost an architectural reproduction of the town of Delft itself, as will be acknowledged by all who can remember that picturesque line of quaint old buildings which once stretched along the Thames between the Archbishop's palace and Vauxhall-bridge, before it was swept away to make room for the Albert Embankment. The Dutch also introduced into Lambeth the manufacture of salt-glazed stoneware, which had been known in England, from the middle of the 16th century, in the form of old jars and flagons popularly called "Grey-beards" and "Bellamines." The details of their decoration show them to have remotely been of Eastern origin; and our modern "Doulton-ware" is, through the imitation of the early Dutch potters of Lambeth, indirectly derived from them.

Doulton's earliest artistic effort in salt-glazed stoneware was the well-known "Toby Jug," which, modified from a Dutch original, had been made at Lambeth from the earliest years of potting there, and was still the typical example of "high art" in Lambeth and Fulham down to 1871. We may laugh at this homely old ale pot now, with its disjointed ornamentation of high-bellied toppers, windmills, and hounds and huntsmen in chase of a stag, but it will always be dear to us of the passing generation from its associations with the days of our youth; and after all it is of an appropriate shape and a fine colour, and it always has a better-proportioned and better-attached handle than is generally seen on our later modern English mugs and jugs, the handles of which are only too frequently undersized, badly modelled, and most carelessly applied.

It was not, however, until 1855, when Sir Henry Doulton had completed his apprenticeship under his father, and began to take a leading part in the direction of the firm, that the first real and important advance was made in the artistic character of the work of the Lambeth Potteries, by the production of terra-cotta garden vases, in both red and buff clay; and a little later attempts were made, on the suggestion of Mr. George Tinworth, to apply incised decoration to small salt-glazed stoneware articles for all kinds of minor uses. Very little progress was, however, made until 1871, when the collection of their work sent by the Messrs. Doulton to the Exhibition, held in that year, at South Kensington took the town, as it were, by storm. Her Majesty the Queen bought half of the tall case of "Doulton ware" shewn; and this was the beginning of the actual trade in the Lambeth art pottery.

Even so far the results were only tentative and uncertain. The body of the ware was still coarse, and the only two colours in use were wholly beyond control in the firing. To obtain purity, brilliance, and variety of colour on so coarse a ground, and under the trying process of burning, was indeed no easy task. But in the end all difficulties were overcome, and at the Vienna Exhibition of 1873, Messrs. Henry Doulton and Co. were able to contribute a series of examples of their artistic stoneware in the final maturity of form and incised sculpture, in which we know it now. His success encouraged him to undertake the revival in Lambeth of the old local Dutch art of underglazed painting on "biscuit," which in the course of 150 years had become completely naturalised in England. As in the case of the "Doulton ware," lady artists were chiefly employed in the decoration of the new Lambeth faience, and by 1885, the last occasion on which I thoroughly went into the matter, close on 400 ladies were engaged in this way in the service of the firm.

These particulars will give some idea of the greatness to which "the Lambeth Potteries," under the administration of the late Sir Henry Doulton, have grown, and of their importance as sustaining the character and promoting the commerce of one of the greatest branches of British art industry. But it is not on this account that Sir Henry Doulton's life-work is chiefly deserving of recognition by his contemporaries; nor is it because of the opening he has made for the occupation of steadily increased numbers of women in a handicraft in which they are so happily fitted by nature to excel, and in a neighbourhood where such employment of female labour had been previously altogether unknown. What we are called upon to honour in him above everything else is, in my humble opinion, his sustained devotion to the principles on which he acted in organising the revival of the old ceramic craft of Lambeth, through the fruitful operation of which it has so rapidly assumed a genuinely indigenous, and national—I should like to say folk—type. These simple principles are two; the first, inspired by the love which Sir Henry Doulton acquired early in life for the use of the potter's wheel, being to make, so far as possible, every piece intended for decoration, on the wheel; and the second, also derived from Sir Henry Doulton's personal experience, to give the utmost scope to the individuality of the designer into whose hands the piece, as thrown from the wheel, in its soft state, is at once passed for decoration. The latter principle was altogether unknown, so far as my reading goes, in modern English commercial art until introduced into "the Lambeth Potteries" by Sir Henry Doulton. Previous manufacturers used to retain the services of a special designer, and when he left them the art of their wares departed with him, or was preserved only in weak and degraded mechanical reproductions. But every one of the 400—there are more now I believe—artists of "the Lambeth Potteries," as I saw them in

1885, was an independent designer, of more or less marked originality, strongly racy of the locality, and representing every kind and degree of ability, which in one or two instances amounted to the creative power of the true artist. In fact we may say that there are 400 distinct styles in the Lambeth art pottery, although all are founded on the teaching of the Lambeth School of Art, under Mr. John Sparkes, the most perfect draughtsmen of strictly conventional floral decoration of our generation. Each artist employed follows the style he or she naturally develops in the practice of the art; and all thus excel according to their capacity, producing that infinite variety of excellence which is the sure criterion of the spontaneous character and vitality of an art. Each artist also signs his or her own work, a most powerful incentive to daily progress in the development of natural gifts. It is in this way that Sir Henry Doulton succeeded in creating a most prolific school, or rather several schools, of English pottery, the influence of which has been felt in the revival of the ceramic arts in all the countries of the Old World, where they had become demoralised during the past 50 years by the prevailing use of machinery in their production.

The influence of Sir Henry Doulton's example in the United Kingdom has been quite marvellous, this country now producing—and it has all been done since 1871—the most artistic commercial pottery of any country in the world.

It is on these considerations that I have ventured to submit to you, with no more detail than is sufficient to justify it, this statement of the enduring claims of the late Sir Henry Doulton to the gratitude and reverence of his fellow-countrymen.

GEORGE BIRDWOOD,

India Office, 19th November, 1897.

General Notes.

IMPERIAL INSTITUTE.—Lord Herschell will preside at the lecture to be given at the Imperial Institute by Sir George Robertson on "The Wild Kafirs of the Hindu Kush," on November 29th, at 8.30 p.m. Members of the Society of Arts will be admitted if they will fill up and present one of the ordinary tickets issued for the admission of friends to the Society's regular meetings.

RUSSIAN PEASANTRY.—Major Craigie, at the last meeting of the Royal Statistical Society, gave a report of the proceedings of the last (sixth biennial) meeting of the International Statistical Institute, held at St. Petersburg, in August and September last. The Russian communications included notices respecting the varied statistics concerning nearly 5,000,000 households locally collected by the Zemstvos, or local councils, and respecting the

many changes which were becoming evident in the condition of the Russian peasantry. Special attention was drawn to the statistics of sales of land in a single year in Russia, which showed that in twelve months 5,646,000 acres had been sold by the nobles, and only about half that area repurchased, something like 2,700,000 acres thus passing out of the nobles' hands into those of peasants of various grades, co-operative associations of peasants and local communes, as well as purchasers of the merchant class. The most interesting features of the population statistics related to the proposals for a synchronous census of the different States of the world in 1900, and to the account, given by M. Troitsky, of the carrying out of the general Russian census of 1897, which showed the population of the empire to have risen to 129,000,000.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

DECEMBER 1.—"The American Bicycle—the Theory and Practice of its Making." By PROF. LEONARD WALDO, D.Sc. SIR OWEN TUDOR BURNE, G.C.I.E., will preside.

DECEMBER 8.—"The Stockholm Exhibition of 1897." By BENNETT H. BROUGH. THE RIGHT HON. SIR BERNHARD SAMUELSON, Bart., F.R.S., will preside.

DECEMBER 15.—"The Purification of Sewage by Bacteria." By SAMUEL RIDEAL, D.Sc. SIR DOUGLAS GALTON, K.C.B., F.R.S., will preside.

Papers for meetings after Christmas :—

"The Protection of Industrial Property." By J. F. ISELIN.

"The Projection of Luminous Objects in Space." By ERIC BRUCE, M.A.

"Aeronautics." By CAPTAIN B. BADEN-POWELL.

"Stage Mechanism." By EDWIN O. SACHS.

"The Recent History of Papermaking." By CLAYTON BEADLE.

"The Preparation of Meat Extracts." By C. R. VALENTINE.

"Children's Sight." By R. BRUDENELL CARTER, F.R.C.S.

"Fireproof Construction." By THOMAS POTTER.

"Compensation to Workmen." By A. D. PROVAND, M.P.

"The Production of Low Temperatures." By Dr. CARL LINDE.

"The Cinematograph." By JULES FUERST.

"The Present Condition of the Sugar Industry." By T. R. TUFNELL.

INDIAN SECTION.

The meetings of this Section will take place on the following Thursdays, at 4.30 or 8 o'clock :—

January 20, February 17, March 10, 31, April 28, May 19.

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesday afternoons at 4.30 o'clock:—

January 18, February 15, March 15, April 5.

APPLIED ART SECTION.

The meetings of this Section will take place on the following Tuesday evenings, at 8 o'clock:—

January 25, February 22, March 8, 29, April 26, May 17.

CANTOR LECTURES.

The following courses of Cantor lectures will be delivered on Monday evenings, at Eight o'clock:—

Dr. EUGENE F. A. OBACH, F.I.C., F.C.S., M.I.E.E., "Gutta Percha." Three Lectures.

LECTURE I.—NOVEMBER 29.

The Raw Material.—The year 1847—Early history and the Society of Arts—General properties and distinction from Caoutchouc—Botanical derivation and geographical distribution—Expeditions in search of gutta trees and experimental cultivation—Analysis of particular specimens and of various commercial brands—Exports from Singapore, imports into the United Kingdom and fluctuation of prices.

LECTURE II.—DECEMBER 6.

The Cleaning Processes.—Mechanical cleaning process—Loss during mechanical cleaning—Chemical washing process—Chemical hardening process—Extraction from raw material and from leaves by means of solvents—Advantages and disadvantages of the different processes—Natural substitutes for gutta percha.

LECTURE III.—DECEMBER 13.

The Clean Material.—Chemical composition, mechanical and electrical properties—Application for various technical purposes—Use of hardened gutta percha for golf balls—Absorption of oxygen and behaviour towards ozone—Deterioration and preservation—Artificial substitutes for gutta percha—Concluding remarks.

CYRIL DAVENPORT, "Decorative Book-binding." Three Lectures.

January 24, 31, February 7.

HUGH STANNUS, "The Principles of Design in Form." Four Lectures.

February 14, 21, 28, March 7.

PROF. W. NOEL HARTLEY, F.R.S., "The Thermo-Chemistry of the Bessemer Process." Three Lectures.

March 14, 21, 28.

DR. D. MORRIS, C.M.G., "India Rubber." Two Lectures.

April 18, 25.

PROF. CARUS WILSON, "Electric Traction." Four Lectures.

May 2, 9, 16, 23.

JUVENILE LECTURES.

Two Lectures, suitable for a Juvenile audience, will be delivered on Wednesday evenings, the 5th and 12th of January, at Seven p.m., by WILLIAM RAMSAY, Ph.D., F.R.S., on "Fire."

MEETINGS FOR THE ENSUING WEEK.

MONDAY, NOV. 29... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. Eugene F. A. Obach, "Gutta Percha." (Lecture I.—"The Raw Material.")

Imperial Institute, South Kensington, 8½ p.m. Sir George Scott Robertson, "The Wild Kafirs of the Hindu Kush."

Actuaries, Staples-inn-hall, Holborn, 7 p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. W. Wallis, "The Pre-Raphaelite Art of Sir John Millais."

TUESDAY, NOV. 30... Civil Engineers, 25, Great George-street, S.W., 8 p.m., Messrs. Hugh L. Callendar and John T. Nicolson, "The Law of Condensation of Steam."

Royal Society, Burlington-house, W., 4 p.m. Anniversary.

Zoological, 3, Hanover-square, W., 8½ p.m. 1. Mr. H. H. Brindley, "Regeneration of the Legs in the *Blattida*." 2. Mr. G. A. Boulenger, (i.) "A Gigantic Sea-Perch (*Stereolepis gigas*). (ii.) "Description of a new Tortoise of the Genus *Sternotherus*. 3. Mr. F. V. Kirby, "Remarks upon a Mountain Reedbeek from the Eastern Transvaal."

WEDNESDAY, DEC. 1... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Prof. Leonard Waldo, "The American Bicycle: the Theory and Practice of its making."

Geological, Burlington-house, W., 8 p.m.

Entomological, 11, Chandos-street, W., 7 p.m.

Archæological Association, 32, Sackville-street, W., 8 p.m.

Obstetrical, 20, Hanover-square, W., 8 p.m.

THURSDAY, DEC. 2... Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Prof. Arthur Dendy, "The Anatomy of *Caudina coriacea*." 2. Messrs. W. West and G. S. West, "Some Desmids from the United States." 3. Exhibitions: (i) Prof. J. B. Farmer, Specimens of Galls of *Cecidomyia*; (ii) Mr. Martin Woodward, an Egg of *Echidna*.

Chemical, Burlington-house, W., 8 p.m. Dr. F. E. Matthews, "Colliers' Space Formula."

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. Silvanus P. Thompson, "Signalling across Space."

FRIDAY, DEC. 3... Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. Grote Stirling, "Permanent Way: its Construction and Relaying."

Geologists' Association, University College, W.C., 8 p.m. Rev. Dr. A. Irving, "Notes on the Geology of the Stort Valley (Herts and Essex), with Special Reference to the Plateau Gravels."

Quekett Microscopical Club, 20, Hanover-square, W., 8 p.m.

SATURDAY, DEC. 4... Holloway College (at the House of the Society of Arts), 11½ a.m. Conference.

Journal of the Society of Arts.

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FRIDAY, DECEMBER 3, 1897.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****CANTOR LECTURES.**

On Monday evening, November 29, Dr. EUGENE OBACH, F.C.S., delivered the first lectures of his course on "Gutta Percha." The lectures will be published in the *Journal* during the Christmas recess.

APPLIED ART SECTION.

A meeting of the Committee of the Applied Art Section was held Wednesday afternoon, 1st inst. Present:—Sir Geo. Birdwood, K.C.I.E., C.S.I.; C. Purdon Clarke, C.I.E., Alan S. Cole, Lewis F. Day, I. Hunter Donaldson, W. Gowland, Lasenby Liberty, J. Hungerford Pollen, Vincent J. Robinson, C.I.E., John Sparkes, and William L. Thomas, with Sir Henry Trueman Wood, Secretary of the Society, and Henry B. Wheatley, Secretary of the Section.

Proceedings of the Society.**THIRD ORDINARY MEETING.**

Wednesday, December 1, 1897; Major-Gen. Sir OWEN TUDOR BURNE, G.C.I.E., K.C.S.I., Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Mehta, R. D., C.I.E., 55, Canning-street, Calcutta
 Milnes, William Henry, 56, Croftdown-road, N.W.
 Morton, George Arthur, 22, Ridley-villas, Newcastle-on-Tyne
 Penton, Edward, 1, Mortimer-street, W.
 Stansfield, Alfred, B.Sc., Aldersyde, Hainault-road, Leytonstone, E.
 Stearn, Charles Henry, Avoca-lodge, Branstone-road, Kew-gardens
 Steel, Fred W., Tamunua, Navua-river, Fiji
 Whitlock, Alfred Allen, Park-street, Dover
 Woods, Henry, A.R.A., Venice

The following candidates were balloted for and duly elected Members of the Society:—

Allen, Herbert J., care of Messrs. Mowlem and Co., City and South London Railway, 7, Denman-street, London Bridge, S.E.
 Alton, James Poë, Elm, Grosvenor-road, Dublin.
 Ansell, Hubert, 75, Lombard-street, E.C.
 Baird, Sir Alexander, Bart., Urie, Stonehaven, N.B.
 Barr, John, Dinting, near Manchester.
 Barratt, James, care of Messrs. Baxter and Sadler, 14, Market-buildings, Flinders-lane, Melbourne, Victoria.
 Beach, Alfred Edward, Toddington, Winchcombe.
 Birdwood, Herbert Mills, C.S.I., 52, Stanhope-gardens, Queen's-gate, S.W.
 Boyd, Rev. Henry, D.D., Hertford College, Oxford.
 Braby, Newton, Bushey-lodge, Teddington.
 Bunting, W. Lightfoot, Quarry-hill, Accrington.
 Burton, William, The Hollies, Clifton-junction, near Manchester.
 Busk, Stephen, 30, Upper Brook-street, W.
 Carter, W. T., 10, Hare-street, Calcutta.
 Dale, Charles James, Denby, Haslemere-road, Crouch-hill, N.
 Dalton, Rowland Neale, Hillside, Lindfield-gardens, Hampstead, N.W.
 Darbshire, William Arthur, D.L., J.P., Penybryn, Carnarvon.
 Deas, Cairns, 7, Hastings-street, Calcutta.
 DeBavay, Aug., Foster Brewery, Colingwood, Melbourne, Victoria.
 Dickinson, William, Sunny-mount, Guildford.
 Diefenbach, J. von, Stuttgart, Wurtemburg.
 Durand, H. E. Sir Henry Mortimer, K.C.S.I., K.C.I.E., Tehran, Persia.
 Fanta, Ferdinand, 97, Queen Victoria-street, E.C.
 Ferguson, William Bates, M.A., 3, Plowden-buildings, Temple, E.C.
 Ferrand, Surgeon Lieut.-Colonel Edward, M.D., Bherampore, Madras.
 Field, William, M.P., Blackrock, Co. Dublin.
 Fields-Clarke, George Thomas, Southill-park, Biggles-wade.
 Finney, S., E.B.S. Railway, Sealat, Calcutta.
 Fitch, Frederick George, Pines, Enfield.
 Ford, Robert Thomas, Sunbeams, Windermere.
 Francis, Harry, Waterworks offices, Devonport.
 Franklin, L., 19, Gower-street, W.C.
 Garnett, Professor William, Technical Education Board, London County Council, St. Martin's-place, W.C.
 Gaster, Léon, 37, Maida-vale, W.
 Gill, Francis N. G., care of Messrs. Binney and Co., Madras.
 Gout, George, Beilby-house, Cleethorpes, Lincolnshire.
 Hacking, William Henry, The Grange, Clayton-le-Moors, near Accrington.
 Halliwell, Edward, Alexandra-crescent, Dewsbury.
 Hanks, Louis, 39, Berners-street, W., and 18, Penmark-road, Ealing Dean, W.

Harral, Horace, Harris's Hotel, Queen-square, Bath, and Union Bank, Chancery-lane, W.C.
 Harris, Frederick William, 81, Gracechurch-street, E.C.
 Harvey, Francis G., care of Messrs. A. W. Perot and Co., Georgetown, British Guiana.
 Hodgson, Hon. H. Perceval, Kullakamby, Nilgiris, Madras Presidency.
 Hodson, William, 7, Finsbury-square, E.C., and Ecclesfield, Seven Sisters'-road, N.
 Holliday, Thomas, Lunnclough-hall, Huddersfield.
 Hoy, Peter, 7, Park-place, Clarence-gate, N.W.
 Hughes, W., Chapâk, Madras.
 Ingram, Frederick William, 237, Walworth-road, S.E.
 Johnston, Alexander R., 370, North Woodside-road, Glasgow.
 Lacey, Joseph Melville, Berampur, Ganjam, Madras.
 Latham, William, M.A., Q.C., 11, New-square, Lincoln's-inn, W.C., and 36A, Rosary-gardens, S.W.
 Law, James, Lieut. R.E., Stanley-house, Farnborough, Hants.
 Lawson, Robert, 133, Stephen's Green, Dublin.
 Lethbridge, Alfred Ernest, Russell-buildings, Frankfort-street, Plymouth.
 Lumb, Tom Gallon, Newton-hall, Poulton-le-Fylde.
 Lundholm, Carl Olof, Stevenston, Ayrshire, N.B.
 Lyell, David, West-park, Chesterfield, Derbyshire.
 Mabey, Frederick Oscar, 196, Amhurst-road, Hackney, N.
 Martyn, Thomas Graham, 11, Stratton-terrace, Truro, Cornwall.
 Mayson, C. M., 7, Scotch-street, Whitehaven.
 Müller, Henry A. C., Keughtung, S. Shan States.
 Neal, Robert Henry Bennett, Central Exchange, Plymouth.
 O'Dwyer, Michael Francis, I.C.S., Alwor, Rajputana, India.
 Oliver, Professor Thomas, M.D., 7, Ellison-place, Newcastle-on-Tyne.
 Paget, Clarence George, Guildford-house, London-road, Croydon.
 Pearce, James Edward, Craufurd, Maidenhead.
 Peck, Herbert Edgar, 65, South Molton-street, W.
 Phillips, John Henley Shawe, 33, Bridge-avenue, Hammersmith, W.
 Pilley, Thomas William, 33, Grove-hill-road, Denmark-hill, S.E.
 Purvis, Peregrine, The Cedars, Winchmore-hill, N.
 Robinson, J. Clifton, Pasadena, 345, Goldhawk-road, Shepherd's-bush, W.
 Scott, Harry, 3, Brixton-hill, S.W.
 Sherwin, H. H., Waddesdon, Aylesbury.
 Shurmur, William, 4, Prospect-hill, Walthamstow, Essex.
 Simpson, E. Graham, 99, St. Martin's-lane, W.C.
 Smith, George Williams, 29, St. George's-road, Eccleston-square, S.W.
 Sperati, Guiseppe E., Rosa Alba-house, Highbury-park, N.
 Stevens, Benjamin Franklin, 4, Trafalgar-square, W.C.
 Stewart, Jeffrey, 35, Argyle-road, Ilford, Essex.

Sykes, Joseph Charles, 15, Vernon-road, Clapham, S.W.
 Sykes, Captain P. Molesworth, Elcombs, Lyndhurst, Hants.
 Tate, Henry, Park-hill, Streatham common, S.W.
 Thomason, William, junr., 162, Elms-road, Clapham-park, S.W.
 Tremearne, Shirley, 8, Old Court-house-street, Calcutta.
 Triana, Santiago Perez, 96 and 98, Leadenhall-street, E.C.
 Vaughan, J., 16, Manville-road, Tooting, S.W.
 Vérel, William Aristides, Fairholm, Larkhall, N.B.
 Wade, James L., 28, West Kensington-gardens, W.
 Watson, William Hill, Hygeia, Windsor-road, Willesden-green, N.W.
 Westland, Sir James, K.C.S.I., Finance and Commerce Department, Simla, India.
 Whittome, D. Knights, The County Studio, Hereford.
 Whowell, F., Carr-bank, Tottington, Bury, Lancashire.
 Wilkinson, C. E., 36, Blythe-road, West Kensington, W.
 Wyatt, Arthur W., Ivor, Goldhurst-terrace, Kilburn, N.W.

The paper read was—

THE AMERICAN BICYCLE: ITS THEORY AND PRACTICE OF CONSTRUCTION.

BY LEONARD WALDO, D.Sc. (Harv.)

Over the portals of a great nation are written in armaments of steel the words *Dieu et mon droit*. Enshrined in the hearts of another great nation and crystallised from the furnace of war are those other words *E pluribus unum*. The one sentiment has built an industrial condition founded on the growth of the individual mechanic, whose personal handiwork should remain a large part of the value to be sold in England's products to the rest of the world, whilst the second sentiment has led where possible to the abdication of the direct result of hand labour, and has sought for the magnification of such labour by the substitution of the automatic machine, whose intelligence is that of the single man, but whose output is that of a hundred men working with untired muscle and ever-fresh brains. Eleven years ago, and before an equally distinguished audience in this hall, we considered the application of machinery to the piece-making of watches according to what was then known as the American plan; to-night we shall consider an application of the same system, but in a larger field of engineering.

We are apt to mistake the true relation of the bicycle to the human economy. There are two broad channels through which human efficiency becomes available, one by utilising energy exterior to ourselves, as in the driven horse or the water power at Niagara; and the other where the entire energy is derived from the human frame, and is made skilful and useful without magnification, but with an economy for the direct object in view, which is proportioned to the energy which can be saved from apparently necessarily connected and attendant operations. If a man can move without the loss of energy of lifting and stopping his feet at each step, he has gained an important economy of energy.

Now man is profoundly interested in anything which is strongly individual, and which is a virtual extension of his own powers. The Tourte bow is none too good for the violinist. The utmost care is given to the shape of the sculler's oar. A half ounce addition is destructive to an individual tennis-racquet.

It is this principle of individuality which separates the skate and the bicycle from all other means of transportation. No energy is added, none can be added. The chemical energy of digesting and, therefore, combusting food, is absolutely all there is, and yet the man moves with the speed of the railway express. Is it a wonder that with the rapid passing of the contrivance and toy to the splendid machine of 1898, in which is incarnate the highest state of the art in every single mechanical procedure involved in its production, there should be a history of mechanics for the period concerned?

See the first safety—whether tinkered by the Scotch cooper, Gavin Dalzell of Lesmahagow in 1846, or made earlier by McMillan of Courthill and Dumfries, I know not—certain it is that the low wheels, the front-steering, the back-driving, the mud-guard are all in it—everything but that other name for a portable good road, the pneumatic tire.

What fun old Dalzell had with his machine! The royal mail coach was pledged to its ten miles an hour, and, when it lumbered into sight, out Dalzell would get with his machine, and before, behind, would go cavorting, rousing the horses to trembling fear and the passengers to excited bets as to which could win, then disappearing in the roadway ahead to the consternation and disgust of every one but Dalzell. Good oak, good sense, what we should now call weak iron and honest work went into this first safety; but after it came an

evolution of bicycle distortion compared to which the evolution which led to the megatherium was a continued line of grace and beauty. I cannot go into this in an evening's paper, for it is the present we have much with us in the bicycle, and the history is in the books; especially in that most excellent of all books by Mr. Archibald Sharp, against which an American might file the complaint of scant attention to the American wheel.

Let us now enter upon the more technical ground of considering along what lines the manufacture of the bicycle must lie, and first how are scientific measures to be made which shall allow the constructor to express in exact numbers the progress he is able to make toward all the perfection which the state of the art allows in the individual parts. We are accustomed to think of the locomotive as a high expression of mechanical art; there is not a single part of the locomotive which has anything like the care in the selection of materials and the crucial testing which is given to the bicycle. The locomotive may be honeycombed with castings about its various parts. It is the fundamental axiom of the best American bicycle construction that every single piece is forged hot or drawn cold. The carbon and phosphorus of the steel in locomotives may vary within wide limits; in the bicycle the variation is small, and the steel is transformed into another and much stronger steel by the addition of 5 per cent. of nickel. In the locomotive the tubular construction may be irregular as to size, and drawn by regular draw bench methods. In the bicycle nickel steel tubing must be cupped up from the disc and drawn by special hydraulic presses of enormous strength and exquisite precision.

It is not as an assemblage of parts that we must finally regard the bicycle. Like the violin it is as an organic whole, under live tension, ready to answer the slightest muscular call, that it must be considered. The testing department, therefore, first regards the materials of construction, and then the machine as a whole. In our illustrations we shall see the successive stages of the preparation of nickel steel tubes. We have in such tubes the maxima of resistance to bending and breaking and crystallization under continued jar, with the minima of weight; but to reach this conclusion many thousands of tests of materials of all kinds had to be made.

Begin with the very tempting metal, aluminium. Pure, in drawn tubes, it has the specific gravity of 2.7, while steel has 7.9, so that an

aluminium tube weighs but one-third of the same sized steel tube. Its strength, soft-drawn, does not much exceed 20,000 lbs. per square inch, under most favourable circumstances, and this might be improved by the addition of something less than 5 per cent. of nickel or copper. Unfortunately, however, the metals of the aluminium class have no well defined elastic limit. When a strain which may not be one quarter of the ultimate breaking strain is applied, the metal begins to stretch, and does not wholly recover when the strain is removed. Now let us approximate, for the purpose of comparison, by assuming that an aluminium-nickel alloy tube can be made, which, in its soft and annealed state will stand 10,000 lbs. per sq. inch without stretch or set, it would have three times the bulk and clumsiness of the nickel-steel tube, and not one-half, probably not one-quarter the resistance to deformation or set under strain, even it were the same weight as steel. If the use of aluminium is advocated to lighten the frame, and sizes approaching those of steel tubes are used, then the comparison is still more unfavourable, so that the aluminium-nickel taken may have only one sixth or even one-tenth of the resistance of the nickel steel. One point must constantly be borne in mind in thinking of the material to be used in bicycle frames. It must all be reduced to the soft or annealed state. The frames have to be assembled and brased at their joints. If the tubes are hard, the heat of brasing anneals them at such joints, and the frame is unequally strong throughout. If the attempt is made to assemble the frame by screw joints, without heat, then it is only a question of time for the racking of the frame in one to start the threaded joints and render the whole frame less taut. Thus nickel-steel tubing is drawn in the tube department of the Pope works at Hartford, which sometimes reaches the enormously high tensile strength of 250,000 lbs. per square inch in its hard state, and to a certainty of gauge not exceeding a variation of 5 per cent. from the gauge thickness. With such a strength the present ordinary steel frame could be one-sixth its present weight, but it would not be good practice to so make it. The tube is immediately brought to a condition known among metal workers as that of "dead soft," *i.e.*, as free from any temper as possible, and so that no further change can take place when the tubes are heated in brasing.

There is another reason for this, and one which reaches into the molecular physics of

steel. One of the usual tests for steel tubes at the works mentioned is to clamp one end of a tube, which may be two or three feet long, in a rapidly driven lathe chuck, and leave the other end free to turn on a fixed dead centre. A strong pressure by a rolling wheel is brought against one side of the tube at its middle and securely clamped, so that at every revolution of the tube it must bend at its middle point. Steam power is then applied, and the number of hundred thousand turns, and consequent bends which the tube will stand before breaking is noted by automatic counters. This number is an indication of the fatigue, the jars, and checks the metal will undergo without taking a set or breaking. A somewhat similar method of torture is applied to the whole frame of the bicycle after the parts have been brased together. In this latter case the base of the frame is securely clamped, as we shall see in our illustrations later in the evening, and a twisting around a circle motion given to the free top of the frame by steam power, so that it is racked in every direction. Here too, the number of twists the whole frame stands is automatically recorded.

If the large class of bicycle riders who firmly believe that a bicycle is a thing animate, possessing a disposition and an obstinacy peculiarly of its own, should form a society for the prevention of cruelty to bicycles, there is no such field in existence as the testing department of the bicycle company named, under its chief inquisitor, the engineer of tests, Mr. Henry Soucher. Not a bicycle which enters that domain lives to tell the tale. Not only are the individual parts racked and pulled with a knowledge of metallurgical anatomy, but the completed machine is clamped against a spring to a rigid frame, and then two rotating wheels with projecting blocks in their circumferences are brought directly under and against the wheels of the bicycle to be tested. Steam power, again applied, gives the bicycle wheels the continuously repeated hammering of the rapidly-turning lower wheels with the projecting blocks. The roughest cobblestone pavement under the speeding machine of the scorcher is very mild treatment in comparison with this roughest of roads fast driven under the spring-loaded bicycle. Here, too, the hundreds of miles and corresponding revolutions are automatically registered to the destructive point of the weakest part of the wheel.

Once, in going through the splendid testing laboratory of McGill University in Montreal,

I heard the late Eckley B. Coxe, one of the most loveable and brightest of our American engineers, say: "Why do we always test small parts of bridges and machines? Why don't we build an entire bridge truss, and then break it down—or test the shaft of a steamship at full size?" He had in mind that no metal construction can grow from the small to the large state with all of its section strengths unchanged.

The test bar, half-an-inch in diameter, gives a far more favourable indication of strength than a bar cut from the solid part of a full-sized casting weighing tons, of the same material. It is important that the strength of the whole be known and determined, and it is only possible to do this by regarding the bicycle as a unit and testing the assembled machine to destruction. This is the theory and also the practice of our greatest company, not only with reference to their own construction, but, for comparative knowledge, with reference to such forms as may be prepared by others.

Besides a system of tests which shall indicate necessities of the strengthening of parts so that the factor of safety may be the same throughout the bicycle, there is another system of tests having in view a totally different purpose, namely, the loss of work and energy which occurs in the bicycle under its normal load, and meeting a varying resistance at varying speeds. We shall see later upon the screen photographs of the beautifully accurate Webb floating dynamometers, built for the department of trade of the Pope Manufacturing Company, by which Professor Denton, of the Stevens Institute of Technology, has made the first valuable contribution to our knowledge of the actual efficiency of types of bicycles.* There appeared at the last (Hartford) meeting of the American Society of Mechanical Engineers papers on and a discussion of the efficiency of bicycles, and these papers, together with Professor Denton's, must be taken as the beginning of our technical special investigations into the energy economies of the bicycle. Professor Denton's curves showing for varying foot-pounds of energy delivered to the bicycle crank, and for varying foot-pounds of resisting energy put on the brake, and which represents the resistance to be overcome by the rider under varying conditions, are in these diagrams correlated to the curve of efficiency, which shows the per cent. of the

total energy exerted by the rider, which is utilised in moving the bicycle forward. So much interest has been roused by the final success in building automatic gear-cutting machinery, so that the direct-gear bicycle is now permanently in the certainties of American manufacture, that I quote you the results of Professor Denton's investigations, referring you to the published paper for its details. He says:—

"The results of the investigation show that both the Columbia chainless wheel and the Columbia chain wheel wastes in its propelling mechanism from about 15 per cent. at high speed (30 miles per hour), and on low grades to 7 per cent. at moderate speeds (13 miles per hour), and on heavy grades of the power applied at the cranks by a rider weighing about 180 pounds, provided the chain of the chain wheel is cleaned and well lubricated.

"Any difference of efficiency of the two styles of propelling mechanism with a clean, lubricated chain is equalled by the difference liable to exist in the power absorbed by two tires of the same grade, which is about 1 per cent. of the average power expended by a rider.

"It is probable that the efficiency shown by the chainless wheels in the tests will be maintained for long periods of road use without any cleaning or lubrication of the mechanism, but the efficiency of the chain wheels, after a short road use, may be considerably less than that shown by the tests by the soiling of the chain.

"The tests of other makes of chainless wheels show that differences in the power wasted by different constructions of tire and by lack of proper stiffness of frame, combined with an arrangement of the gears whose efficiency is affected by the distortion of the frame by crank thrust, may make the waste of power reach 50 per cent. of the energy applied to some chainless wheels at high speeds on low grades."

I have gone thus at some length into the forms of testing in the typical and greatest of our American works, because if a knowledge of facts is the foundation of science, it is especially the foundation of bicycle structure; and the art is too new to have a literature or established traditions.

The next thing after the laboratory determinations have furnished the data for construction, is the field trial. This is done with the most careful system. Paid riders, with marked routes and blank reports to be filled out in minute detail, are despatched in all kinds of weather and over all kinds of roads. On the screen we shall see later two such riders who have just come in, one on a chainless wheel, and the other with a chain wheel, both over the same rainy, muddy, sandy in parts, and hilly route. From these reports, which are

* *The Iron Age*, No. 7, October 21st, 1897.

endorsed by inspectors in distant towns, the opinion is formed as to the wisdom of constructions planned or new things to be attempted. Single wheels embodying some special idea are thus ridden as much as 15,000 miles under different riders, with an accurate register of every mishap.

One other point ought to be mentioned in this connection, something which for a better name may be called the democratic council.

At least once in every day, and sometimes many times in a day, the ubiquitous inventor appears. It may be the man who is prepared to prove that he takes out four times the energy he puts in, by his particular contrivance, or it may be a thing of merit. Whatever it is, if it is endorsed on a preliminary examination it is fully discussed in a public meeting of riders, salesmen, and general officers, under all the form of parliamentary rules. It has always been the policy of this particular company to avoid the making of what are known as bicycle accessories, with the exception of a hand-kit of small tools, which we shall show later on the screen.

So much for the determination of the facts, and the democracy of the advice. It is not strange that the manufacture should have assumed large proportions; this particular company has as high as 3,800 names on its pay-rolls at times, its buildings are spread over 19 acres of the city of Hartford, and its

investment is estimated at £1,000,000. The output per day reaches 600 finished bicycles in the busy season, and preparations are making to extend this output with the advent by most of the principal makers of the chainless wheel.

All of the essentially American characteristics of such highly organised machine-working companies are carefully carried out. Plenty of clear day-light in every department; lunch rooms, where at cost price soups and the essentials of a hot meal are furnished by the company's cooks; rooms with comfortable fittings of tables and chairs, with good literature or games for the leisure hours; long separate water tanks for easy washing, and separate lockers for those who wish to keep clothes or property under private lock and key; strikes unthought of; the clear sunlight through long hours; every man at his machine or his dozen machines—his only thought and pride that it be of the best of its kind! Oh, sons of England, that you could only see in your striking work meetings that your work interests and your capital interests are the same. Not always will there be a high protective tariff in the United States for the benefit of European industries in the markets of the world. When that day comes and scales of value are the same in the civilised world, you will miss the help of the multiplying machinery which you now refuse.

TABLE I.—COPY OF TEST SHEET No. 35.

Driving Flat.

Description of Wheel. Test No. 1.	Time in seconds per 100 revolutions.	Revolutions of cranks per minute. <i>N</i> .	Reading of counter- poise c.m. <i>s</i> .	Foot-pounds delivered to crank. $2 n S$	Average foot- lbs.
<i>I</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>
1. Model 50, Pope chainless, tire A	36'2	165'8	18	5,900	6,116
2. Gear $71\frac{1}{2}$ = G	37	162'2	30 8	9,992	9,897
3. Weight on saddle = 183 pounds = <i>L</i>	37'8	158'7	48'8	15,489	15,300
4. Diameter of tire, 60 pounds air pressure, before loading = $27'65 = D^0$	38 8	154'6	65	20,098	20,046
5.	40'4	148'5	82'5	24,502	24,484
6. Diameter of tire, 60 pounds air pressure, after loading = $27'35 = D$	39'4	152'3	82'4	25,099	—
7.	38	157'9	64'5	20,369	—
8.	37'4	160'4	48'5	15,559	—
9. Rolling radius of tire = $\left[\frac{D_0}{2} (D_0 - D_1) \right]$	37'2	161'8	30'0	9,105	—
10. Circumference of track wheel = 63 inches	36'2	165'8	18 3	6,068	—
11. Ratio of revolutions of track wheel to revolutions of crank if there was no tire slip = <i>C</i>	35'8	167'6	19'1	6,402	—
12.	37	162'2	30'5	9,894	—
13.	37'8	158'7	48	15,235	—
14.	39	153'9	65'1	20,038	—
15.	40'6	147'7	82	24,223	—
16.	41'2	145'6	82 8	24,110	—
17.	40	150	65'6	19,678	—
18.	38'6	155'4	48	14,917	—

TABLE I.—COPY OF TEST SHEET NO. 35 (continued).

Driven Float.

Description of Wheel. Test No. 1.	Revolutions of brake wheel per minute. <i>n</i> .	Reading of counter- poise c.m. <i>s</i> .	Grade in per cent. equivalent to values of <i>s</i> for 175 lb. rider. <i>g</i> .	Foot-pounds utilised.			
				By brake. 2 <i>N s</i> .	Aver- age.	By track wheel.	Total Col. 11 + Col. 12.
	7	8	9	10	11	12	13
1a							
1. Model 50, Pope chainless, tire A	555	1'5	0'33	1,665	1,707	915'1	2,622'1
2. Gear 71 $\frac{3}{8}$ = <i>G</i>	544	5	1'11	5,440	5,412	883'8	6,301'8
3. Weight on saddle = 183 pounds = <i>L</i>	530	10	2'06	10,600	10,571	860'2	11,440'2
4. Diameter of tire, 60 pounds air pressure, before loading = 27 65 = <i>L</i> ⁰	519	15	3'02	15,570	15,437	846	16,281
5.	496'5	20	3'97	19,860	19,585	805'2	20,390'2
6. Diameter of tire, 60 pounds air pressure, after loading = 27 35 = <i>D</i>	502	20	...	20,080	—	—	—
7.	521	15	...	15,570	—	—	—
8.	533	10	...	10,660	—	—	—
9. Rolling radius of tire = $\left[\frac{D_0}{2} (D_0 - D_1) \right]$	537	5	...	5,370	—	—	—
10. Circumference of track wheel = 63 inches	555	1'6	...	1,776	—	—	—
11. Ratio of revolutions of track wheel to revolutions of crank if there was no tire slip = <i>C</i>	Average = 523'54 31'234 miles per hour.	1'5	...	1,678'5	—	—	—
12.	542'5	5	...	5,425	—	—	—
13.	530	10	...	10,600	—	—	—
14.	518	15	...	15,540	—	—	—
15.	490	20	...	19,600	—	—	—
16.	470	20	...	18,800	—	—	—
17.	500	15	...	15,000	—	—	—
18.	521'3	10	...	10,426	—	—	—

Slip Data and Efficiency.

Description of Wheel. Test No. 1.	Slip data.		Efficiency.	
	$C = \frac{2 \pi}{63 \times 28} G \left[\frac{D_0}{2} - (D_0 - D_1) \right]$		With Slip.	For zero slip.
	$\frac{N}{n}$	Per cent. of slip. $\frac{C}{100} \frac{N}{n}$	Col. 13 Col. 6 100	Col. 16 100 - Col. 15
1b	14	15	16	17
1. Model 50, Pope chainless, tire A	3'348	3'88	42'66	44'43
2. Gear 71 $\frac{3}{8}$ = <i>G</i>	3'354	3'70	63'67	66'40
3. Weight on saddle = 183 pounds = <i>L</i>	3'340	4'11	74'77	77'97
4. Diameter of tire, 60 pounds air pressure, before loading = 27 65 = <i>L</i> ⁰	3'357	3'62	81'22	84'72
5.	3'344	3'99	83'23	88'00
6. Diameter of tire, 60 pounds air pressure, after loading = 27 35 = <i>D</i>	3'297	5'34	—	—
7.	3'3'0	5'25	—	—
8.	3'323	4'59	—	—
9. Rolling radius of tire = $\left[\frac{D_0}{2} (D_0 - D_1) \right]$	3'319	4'71	—	—
10. Circumference of track wheel = 63 inches	3'317	3'90	—	—
11. Ratio of revolutions of track wheel to revolutions of crank if there was no tire slip = <i>C</i>	3'338	4'16	—	—
12.	3'345	3'06	—	—
13.	3'340	4'11	—	—
14.	3'366	3'36	—	—
15.	3'318	4'74	—	—
16.	3'228	7'32	—	—
17.	3'333	4'31	—	—
18.	3'355	3'68	—	—

TABLE II.—COPY OF TEST SHEET No. 39.

Driving Float.

Description of Wheel. Test No. 1.	Time in seconds per 100 revolutions.	Revolutions of cranks per minute. <i>n</i> .	Reading of counter- poise c.m. <i>S</i> .	Foot-pounds delivered to crank. $2 n S$.	Average foot- lbs.
I	2	3	4	5	6
1. Model 50, Pope chainless, tire A	40'6	73'9	15'1	2,232	2,177
2. Gear $71\frac{2}{3} = G$	41	73'2	28	4,009	4,082
3. Weight on saddle = 183 pounds = <i>L</i>	41'4	72'5	63'2	9,164	9,297
4. Diameter of tire, 60 pounds air pressure, before loading = $27'70 = D_0$	43'2	69'4	131'8	18,294	18,391
5.	44'8	67	183'4	24,573	24,945
6. Diameter of tire, 60 pounds air pressure, after loading = $27'38 = D$	41'6	67'3	186'5	25,102	—
7.	44'4	67'6	186'1	25,159	—
8.	43'2	69'4	133'2	18,488	—
9. Rolling radius of tire = $\left[\frac{D_0}{2} (D_0 - D_1) \right]$	41'4	72'5	63'8	9,250	—
10. Circumference of track wheel = 63 inches	40'6	73'9	27'5	4,064	—
11. Ratio of revolutions of track wheel to revolutions of crank if there was no tire slip = <i>C</i>	41	73'2	14'5	2,123	—

Driven Float.

Description of Wheel. Test No. 1.	Revolutions of brake wheel per min. <i>N</i> .	Reading of counter- poise c.m. <i>s</i> .	Grade in per cent. equivalent to values of <i>s</i> for 175 lb. rider.	Foot-pounds utilized.			
				By brake $2 N s$	Average.	By track wheel	Total Col. 11 + Col. 12
Ia	7	8	9	10	11	12	13
1. Model 50, Pope chainless, tire A	247	1'1	0'33	543	521	407'8	928'8
2. Gear $71\frac{2}{3} = G$	244	5	1'11	2,440	2,455	403'7	2,858'7
3. Weight on saddle = 183 pounds = <i>L</i>	239	15	3'02	7,170	7,185	393'8	7,578'8
4. Diameter of tire, 60 pounds air pressure, before loading = $27'70 = D_0$	233	35	6'68	16,310	16,240	381'5	16,621'5
5.	222'7	50	9'70	22,270	22,273	366'2	22,639'2
6. Diameter of tire, 60 pounds air pressure, after loading = $27'38 = D$	221'5	50	—	22,150	—	—	—
7.	224	50	—	22,400	—	—	—
8.	231	35	—	16,170	—	—	—
9. Rolling radius of tire = $\left[\frac{D_0}{2} (D_0 - D_1) \right]$	240	15	—	77,220	—	—	—
10. Circumference of track wheel = 63 inches	247	5	—	2,470	—	—	—
11. Ratio of revolutions of track wheel to revolutions of crank if there was no tire slip = <i>C</i>	249	1	—	498	—	—	—

Slip Data and Efficiency.

Description of Wheel. Test No. 1.	Slip data.		Efficiency.	
	$C = \frac{2 \pi}{63 \times 23} G \left[\frac{D_0}{2} - (D_0 - D_1) \right]$		With slip.	For zero slip.
	$\frac{N}{n}$	Per cent. of slip. $\frac{C}{100} \frac{N}{n}$	Col. 13 Col. 6	Col. 16 $\frac{100}{100 - \text{Col. 15}}$
Ib	14	15	16	17
1. Model 50, Pope chainless, tire A	3'342	3'07	42'66	43'62
2. Gear $71\frac{2}{3} = G$	3'333	3'34	70'03	72'35
3. Weight on saddle = 183 pounds = <i>L</i>	3'27	4'38	82'32	85'93
4. Diameter of tire, 60 pounds air pressure, before loading = $27'70 = D_0$	3'357	2'64	90'38	93'23
5.	3'424	3'60	90'76	94'63
6. Diameter of tire, 60 pounds air pressure, after loading = $27'38 = D$	3'291	4'55	—	—
7.	3'314	3'89	—	—
8.	3'328	3'48	—	—
9. Rolling radius of tire = $\left[\frac{D_0}{2} (D_0 - D_1) \right]$	3'310	4'00	—	—
10. Circumference of track wheel = 63 inches	3'342	3'07	—	—
11. Ratio of revolutions of track wheel to revolutions of crank if there was no tire slip = <i>C</i>	3'402	1'33	—	—

TABLE III.—EFFICIENCY AT EQUAL FOOT-POUNDS DELIVERED TO CRANK AS TAKEN FROM CURVES.

	Number of Sheets.	Date of Test.	Gear.	Weight in Saddle, in lbs.	Average miles per hour.	Foot-pounds delivered to Crank as taken from Efficiency Curves on Plates.											
						25,000		23,000		21,000		17,000		12,000		8,000	
						7	8	9	10	11	12	13					
I																	
1 Wheel 1.—No. 80 1½ in. Hartford Tire A	29	Aug. 26	71½	123	13.25	...	93.75	92.75	92.75	90.75	89.62	88.50					
2 Wheel 1.—No. 80 1½ in. Hartford Tire A	30	Aug. 26	71½	183	13.10	...	93.00	92.90	92.50	90.00	88.25	85.50					
3 Wheel 1.—No. 80 1½ in. Hartford Tire B	38	Aug. 28	71½	{ Saddle 63 } { Pedal 120 }	12.93	...	94.00	93.10	92.25	89.00	86.80	83.80					
4 Wheel 1.—No. 80 1½ in. Hartford Tire B	37	Aug. 28	71½	183	12.56	...	...	94.30	93.50	91.20	89.75	87.61					
5 Wheel 2.—No. 80 1½ in. Hartford Tire A	33	Aug. 27	71½	123	12.93	...	93.00	92.75	92.25	90.75	89.75	88.50					
6 Wheel 2.—No. 80 1½ in. Hartford Tire A	34	Aug. 27	71½	183	12.98	...	92.75	92.50	91.95	89.50	87.75	85.00					
7 Wheel 2.—No. 80 1½ in. Hartford Tire A	39	Aug. 28	71½	183	14.01	94.75	94.50	93.75	92.95	89.25	87.10	84.00					
8 Wheel 2.—No. 80 1½ in. Hartford Tire B	31	Aug. 26	71½	123	12.94	...	94.00	93.75	93.40	91.50	90.25	87.50					
9 Wheel 2.—No. 80 1½ in. Hartford Tire B	32	Aug. 26	71½	123	13.12	...	93.75	93.50	93.25	91.50	90.25	88.50					
10 Wheel 2.—No. 80 1½ in. Hartford Tire A	40	Aug. 28	71½	{ Saddle 63 } { Pedal 120 }	13.80	...	94.25	93.75	93.00	90.40	88.50	85.75					
11 Wheel 3.—No. 80 1½ in. Tire 3	37½	Aug. 30	74.75	183	13.86	90.75	90.50	90.10	89.40	86.85	85.10	82.60					
12 Wheel 4.—No. 80 1½ in. Tire C	43	Aug. 31	63.8	183	11.53	...	...	89.50	88.25	84.00	81.25	77.00					
13 Wheel 5.—No. 80 1½ in. Tire 5	42	Aug. 31	65.7	183	11.93	...	...	90.00	89.00	84.25	81.25	77.25					
14 Wheel 1.—No. 80 1½ in. Tire B	36	Aug. 27	71½	183	31.67	...	85.75	83.75	80.00	73.00	67.50	58.75					
15 Wheel 2.—No. 80 1½ in. Tire B	35	Aug. 27	71½	183	31.23	...	86.75	81.25	80.75	72.00	66.10	56.50					
16 Wheel 2.—No. 80 1½ in. Tire A	41	Aug. 27	71½	183	33.6	...	...	83.00	70.25	71.40	66.50	58.00					
17 Wheel 5.—No. 80 1½ in. Tire 5, 42 A	42a	Sept. 1	65.7	183	30.75	...	...	...	65.75	50.25	41.75	...					
Other makers																	
Old chains																	
Foreign „																	
Columbia chainless.....																	
Columbia chainless.....																	
Columbia chain.....																	

The company's works are complete within themselves. The making of rubber tyres, described in *Engineering* by its correspondent, Major Wiley, is carried on for its own benefit, and that of most of the other American companies. Steel tubing, formerly brought from England, is now made in their own tube works to limits of precision in drawing, as follows :—

Tubes 1 in. diameter and over must not exceed the gauge thickness by more than 0.003 in., nor be less than their gauge thickness by 0.001 in. Tubes less than one inch diameter must not exceed their gauge thickness by more than 0.002 in., nor be less than the gauge thickness by more than 0.001 in. In tubes of No. 21 B.W.G. (0.032 in.) and thicker, the gauge extreme variation of thickness does not exceed 0.003 in., and it does not exceed 0.002 in. for tubes less than 0.032 in. thick.

It may interest those present concerned in tube drawing, that these figures are enforced. I cannot, in the limits of this paper, follow the consecutive operations of making the bicycle. You will see on the screen photographic sections of the bicycle in various stages, and I think they will reveal the answer to most of the questions which suggest themselves to your minds. The essential thing to be remembered is that the frame is considered the unit for work. Nothing is done in the way of fitting or centreing any of the parts until the completed frame with its re-inforced joints, with all the brazing, heating, or other distorting influences, is complete. The entire frame is then securely held in gauged clamp vices, and the boring and centreing done by tools also rigidly set to gauge.

The interchangeability of parts under this system is the same as in that other product of American machinery—the American watch. Another point is the nature of the hardening of the spherical bearings on which the balls roll, and I can best consider this with a photo-micrograph of the highly magnified fracture of the broken steel surface before us on the screen. You will then see by the marked difference in granular structure how perfectly the surface hardening has been carried out. As for the balls themselves, they are case-hardened in the same careful manner, and I give below the measures of twenty of them picked up at random, to show the uniformity of manufacture :—

No. of the ball.	Measured diameter.	No. of the ball.	Measured diameter.
	in.		in.
1	0·1878	11	0·1880
2	0·1881	12	0·1880
3	0·1882	13	0·1879
4	0·1880	14	0·1879
5	0·1878	15	0·1880
6	0·1880	16	0·1880
7	0·1882	17	0·1880
8	0·1878	18	0·1880
9	0·1880	19	0·1880
10	0·1880	20	0·1880

Now for the chainless bicycle—the state of the art towards which the American machine methods have been struggling for years back. Three great difficulties had to be overcome to make the venture commercially or technically successful.

First, some material which could be worked into tubes had to be found which should possess the requisite strength, lightness, and resistance to torsion. This material must be worked in machinery specially designed, since no plant existed in which one inch and a half hard-steel tubes could be drawn cold with the necessary precision to give their tubing at 250,000 lbs. per square inch tensile strength or 150,000 lbs. elastic limit. This is the condition of such tubes before annealing.

Second, while involute and epicycloidal gears had been cut on machines, such machines were far too slow, and consequently too costly, to make such gears for the bicycle in the quantities required. It remained for the two great firms of machine tool-makers, the Pratt and Whitney Company, of Hartford, Conn., and the Brown and Sharpe Company, of Providence, R.I., each to bring forward compact machinery which should occupy small floor space, and at the same time automatically cut an epicycloidal or involute shaped tooth at the will of the mechanic in charge. We shall see upon the screen such machines in operation.

Third, a process was to be devised for the hardening of gears, ball, and spherical cup-bearings throughout, which should not, in practice, result in any appreciable deformation of the tooled surfaces.

It has been a surprise to me to find that here in England many regard the chainless wheel

as something new, something radical. It is the chain that is new, not the gear. A generation before the modern bicycle was born the mathematicians had shown theoretically that if spur or conical gear teeth were cut in certain curves, not circular, that power would be transmitted with as small a loss as by any other method. No thinking American mechanic ever analysed the chain bicycle construction without convincing himself that the compact, rigid, tightly-enclosed shaft-power transmission would be adopted for the bicycle whenever rigid enough frames and hard enough gears could be manufactured in a commercial way. The chainless bicycle is neither a discovery nor an invention; it is an evolution, and so far as we can now see, it will be the survival of the fittest. The use of the rigid under strut of the rear triangle as the means of carrying the tube to which are brazed the end gears, is the most elegant solution of the gear-case problem yet proposed. Here you have the gear-case rigid, a little over one inch in diameter, and firmly secured to the thin steel covering caps at each end. The gears may run in a cup of oil, if necessary, and the stiff under strut thus serves the double purpose of part of the frame and gear-case as well. I must bring this part of the paper to a close, leaving details to the explanation of the illustrations on the screen.

It was in 1865 that Pierre Lallement, living in the manufacturing town of Ansonia, first made an American bicycle. He rode from that town to New Haven, fourteen miles, on one; but it was not until 1877 that Colonel Albert A. Pope, after riding a wheel in the Back Bay district of Boston, foresaw its possibilities and founded the great industry of which he has remained the conspicuous chief. He has been justly called the father of the American bicycle. Not that he invented any of its parts, but in the broadest sense he has steadily nurtured the bicycle art in the United States. This, what John Stuart Blackie would call, virtuous energising, has been equally prevailing, whether in the conduct of his great company or whether before State legislatures urging proper measures for good roads, or combating the restrictions of small town councils on bicycle traffic, or urging upon the technical schools and assisting financially technical education, or pushing to effective completion highly-organised and contributory companies, such as the motor carriage department of the Pope Manufacturing Co. You get your peers by heritage, we must find ours by sur-

vival: and Col. Albert A. Pope, when he laid aside the soldier's uniform he had always honoured, at the close of our civil war, entered upon a career which has made him respected alike by those whose business schemes he opposes or advocates, while by his men he is loved, because he has constantly regarded their welfare, and no one can complain of an undressed grievance who had a just cause. It is men of his stamp and mould which constitute our American aristocracy, whether in literature, or pure science, or mechanical art.

DISCUSSION.

Mr. ARCHIBALD SHARP said the Society was to be congratulated on having this subject brought before it in such an interesting manner. The great question in the minds of all interested in cycles was that of chain *versus* chainless driving, to which such prominence had been given in the paper. It was rather curious that before the chain was adopted for the purpose of transmitting motion from the crank shaft to the hub, nearly all engineers looked upon the chain as a most inefficient means of transmitting power; but bicycle makers and riders had taught them that it was perhaps the most efficient mechanical means for transmitting power between two parallel shafts nearly close together. The curves which had been thrown on the screen showed a very high efficiency for both chain and bevel wheel gear; and that in fact they were practically equal. But efficiency was only one of the points which had to be considered in deciding on the suitability of two different types of bicycle gear, and the question whether the bevel gear would be largely adopted in this country would not depend on relative efficiency only. For example, the difference between a full roadster tire and a light roadster tire of the same maker was much greater than any possible difference between the two gears. The use of gear-cases for chains was very usual here, at least on machines used for pleasure and touring, and it seemed to him that the bevel gear had a great advantage in this respect, because a gear-case was always more or less of a nuisance. The very neat and effective gear-case shown on the chainless bicycle was far preferable.

Mr. H. GRAHAM HARRIS said this very interesting paper, for which they were much indebted to Professor Waldo, made the mouths of English engineers water, and many of them would think to themselves that if they had had the same advantages for testing this extremely new mechanical device, they might have attained equally successful results. He had always wondered why Americans preferred wood rims to steel, and the

only reason given in the paper was that the wood rim wore out as rapidly as the tire. It was certainly not the practice of English engineers to prefer wood to steel where the stresses and strains were so varying and so persistent as they were in the rim of a bicycle wheel. It was not unlikely that when tires were improved—as they certainly must be, having regard to their expense at present quite apart from the question of patents, which was a serious item—that even the Americans would find that steel was preferable to wood for the rim.

Mr. J. PENNELL said he was inclined to ask if the Pope Company was the only one manufacturing cycles in the United States, because when he was there last there were half a dozen or a dozen others, who all said they were as good as the Pope Company, and many of them claimed to be much better. He should also like to know why wood rims were used in the United States and nowhere else, except as a matter of fashion, and again, why single-tube tires were used, and whether it was not simply because the Hartford Rubber Company made them and forced them on the public. They all knew over here that the single-tube tire was the worst thing ever devised, and it had been virtually given up. Wood rims might, theoretically, be as good as steel, but his experience when touring last summer with American friends using them, had been that if the tire got a little slack and you came on some rough stones, the wood rim got a great “chunk” taken out of it, and you had to send the machine to the maker for a new rim, whereas a steel rim would not even be bent, or if it were bent it could be easily put right. He had ridden the Columbia bicycle more miles than Colonel Pope himself, having begun about the same time. The crank axle was a beautiful piece of work, much better than the company used to turn out; but even now, if you came over and bent it, what were you to do? It was made all in one piece, and there you had to send the whole crank axle to the company and get a new one. You could not get one made under a week. It was true that American machines, as a rule, had no gear-cases and no brakes, the riders put their toes on the front wheel, and the brakes fitted to American cycles for English use were generally of steel, without a rubber lining, which destroyed the tire. The chainless machine was no doubt beautifully made, but he should like to know how it differed from the French “Acatène.” The Pope Company made beautiful machines, but the difficulty was that, having so many specialties, it was difficult to get them repaired if anything happened to them, without sending them back to the factory. Professor Bishop had recently written to the *New York Nation* an account of his experiences in Europe with a “Columbia” bicycle, the end of which was that he tried in Paris to get rid of it, and tried in vain,

Mr. T. H. BRIGG said there were one or two important questions with regard to the wear and tear of the chainless bicycle which had yet to be solved, and to which no reference had been made. He only heard on Monday of this paper. He had to-night hurriedly made two incomplete diagrams to show the forces operating on bearings of a rear-driven bicycle. He found that the force exerted on the hub sprocket wheel by the chain, assuming the road resistance to be 20 lbs., was 186.6 lbs. That required a force of 86.1 lbs. at the crank or pedal, and as the result you get a force of 173 lbs. exerted on the crank bearings. In the case of the bevel gear, instead of 186.6 lbs. + 20 lbs. = 206.6 lbs., at the rear bearing you get 233 lbs., and on the bearing of the crank shaft 311 lbs., as against 173 lbs. There was, therefore, a great deal of difference in the amount of pressure on the bearings in the chainless and chain-driven bicycle. Of course there were many other questions of great importance which had not been touched; though he had hoped to hear something about them. For instance, there were the physio-logical conditions which ought to govern the designing of bicycles, but which were entirely overlooked for want of information. When these were considered there would be the same ease and comfort in a bicycle as was expected in every other sphere of life.*

Sir CHARLES TUPPER, Bart., G.C.M.G., said he had listened with great pleasure to this most interesting and graphic paper, which he was sure would be of great advantage to the public when printed.

The CHAIRMAN said: Although I have but little to add to the remarks already made on the instructive paper just read to us by Dr. Leonard Waldo, I cannot forego the opportunity afforded me as your Chairman of assuring him of our appreciation of that paper, and of asking you to join me in a cordial vote of thanks to him for his courtesy in coming here this evening to tell us of what is being done in America to bring the machine, in which we are all so much interested, to a gradual but sure perfection. The information that Dr Waldo has given us as to the severe testing process carried on in the Pope works at Hartford, must be of great interest to all bicyclists, not only because it demonstrates the care taken there in manufacture to strengthen all parts of the machine, so that the factor of safety may be the same throughout it, but shows also the precautions deemed necessary to meet the loss of work and energy which occurs in a bicycle under its normal load, as well as to provide for its varying resistance

at varying speeds. In addition to this testing process, the system of trials of new machines, so graphically described by the reader of the paper as in force at the Hartford works, is one which cannot but claim the approval of us all. I am sure that I re-echo your sentiments when I say that we are all truly glad to hear from so good an authority that a chainless wheel, in lieu of the chain gear now in use, is a certainty in the manufacture of future bicycles in America, as it is, we may hope, in this country also, for this direct gearing will be as great an advance in manufacture as it will be in the comfort and safety of bicyclists. Here we have one more curious instance of the fact that there is little or nothing new in this world of ours, as Dr. Waldo assures us that the idea of propulsion without chain gear is an old one affirmed by mathematicians many years ago. I will not take up your time by any further observations, but will, with your permission, assure Dr. Waldo of our cordial appreciation of his kindness in once more coming before us, and of giving us so agreeable and instructive an evening.

The vote of thanks having been carried unanimously,

Prof. WALDO, in reply, said it was far from his purpose to make any invidious comparisons. There were many makers of cycles in the United States, but you had to choose a type, and he thought they would be most interested in following the lines of work in the company which was most widely known as having done the thing so thoroughly. Many of these other companies, and the largest of them, were much more closely related to the Pope Company than appeared; because the license to make the chainless wheel would be taken by almost all the largest American companies. Questions of business or administration, however, were he thought rather foreign to the purposes of the Society, the primary consideration being not who did it, but what was the system under which the thing was done. He had a very brotherly feeling towards Mr. Harris, and must say that from an engineering standard he always felt there must be something wrong about a wooden rim; but, after all, the proof of the pudding was in the eating, and, if the rubber tire and wooden rim belonged to one another, what nature had joined together ought not to be separated. He could not say anything on the point raised by Mr. Brigg, beyond referring to the diagrams, which showed the efficiency of the bevel wheel gear. To the riders who were paid a weekly stipend it was immaterial whether they rode a mule or a horse, but their uniform preference for hard riding had been the new wheel. He did not say that the judgment was an old one, or founded on long experience, because it was only the progress of a number of correlated efforts which had rendered it possible to make it, though the design must have been in the heads of many people long ago.

* Mr. Brigg states that since he spoke at the meeting he has seen reason to change his opinion as to the advantages of the bevel gear. He has completed his diagrams, and now finds an important mechanical advantage in favour of the bevel gear, on the reason for which he is now making investigation.

Miscellaneous.

THE FORESTS OF RUSSIA.

According to the official statistics, the fifty provinces of European Russia contain 39 per cent. of forest land, 25 per cent. of arable land, 16 per cent. of meadow and pasture land, and 19 per cent. of land unfit for use. It appears, therefore, that forest land predominates, but it would be a mistake to call European Russia a wooded country. According to a recent report of the Russian Committee of Ministers, only two regions can be properly described as chiefly composed of forest land, namely the extreme north (59 per cent.), and the Ural region (45 per cent.). The provinces of the Middle Volga and the lake districts are wooded to the same extent as Austria (29 to 30 per cent.), and the following regions are more wooded than France, but less than Germany:—The Moscow industrial districts, the provinces of White Russia, with Lithuania, the kingdom of Poland, the wooded parts of the Ukraine (the provinces of Kieff and Volhynia), and the Transcaucasus (26 to 40 per cent.). The Baltic provinces resemble France (17 per cent.), and in the remaining provinces the proportion of foreign land is still less, although France is considered a thinly-wooded country. Finally on the steppe land of the south-eastern regions there is not more than 1 per cent. of forest. In relation to the number of inhabitants, more favourable results are obtained. There are 3·5 acres of forest to every inhabitant, whereas in Europe in general, there are only 2·1, and in particular in Austria, 1·3, or Germany, ·8, and in France, ·5 of an acre. But if we reckon by zones and districts, more than half of the population have less forest land than in Germany, and one-fifth less than in France. The gross consumption of wood for domestic and industrial purposes is estimated by Professors Roudsky and Shafranof, to be equivalent to the cutting down annually of an area of 2,000,000 dessiatines, or 5,400,000 acres, out of a total of 142,000,000 dessiatines, or 383,000,000 acres, comprising the entire forest area. This destruction of timber could not be considered excessive if the entire area of forest land were equally distributed, but unfortunately this is not the case, and thinly-wooded districts are being denuded of timber with very great rapidity. This deforestation has brought about destructive inundations in the basins of the Dniester, Dneiper, Boog, Don and Western Dvina, which were formerly unknown. Woods and forests also purify atmosphere, arrest the drifting of sand and the formation of dunes, form a protection against the detrimental effects of hail and storms, strengthen the banks of rivers and streams, and prevent the latter from becoming silted up and shallow. This explains the great importance of woods and forests in Russia, which has hitherto been an agricultural country, and in which the well-being of a majority of the inhabitants depends upon equality and moderation of climatic conditions. The history, therefore, of the relations of

the community and the State towards this question of woods and forests is of no small interest. In ancient times the woods and forests of Russia were too abundant to have any value or importance among the thinly scattered population, and were not even regarded as private property. It was not until the end of the 15th century that a beginning was made in this respect by the issue of "preservative charters" to a few landowners against the cutting of wood by unauthorised persons. In the law code of the Tsar Alexis Mikhailovich, there is a general system of punishments laid down against the use of other persons' wood, but it was only in the reign of Peter the Great that the Government began to take decisive measures in regard to the forests of the country. In 1703 all woods and forests within 50 verstes (33·15 miles) of the larger rivers, and 20 verstes (13·26 miles) of the smaller ones were declared to be "zapovirdney," *i.e.*, their destruction was interdicted. Punishment by death was decreed against the cutting down of oak, and ten roubles fine for the destruction of every other kind of tree. With the establishment of a Ministry of State Domains in 1838, the authorities began to attach importance to the existence of woods and forests of the Crown, and to the establishment of a corps of foresters for their proper management and cultivation. The results of these measures, which continue to operate at the present day, were very important, not only in the sense of increasing the income of the State, but in its general interests, as the extent of forest land owned by the State is immense. In European Russia alone the State owns two-thirds of all the woods and forests. On the establishment of the zemstvos, in the sixties, many of the assemblies of these institutions raised the question of forest preservation, in which they received the strong support of the Minister of State Domains, Count Valoeief. The first laws for the preservation of forests were then drawn up, but these were confirmed by the Emperor only in 1888. By these laws the following forests and coppices may be recognised as protected throughout European Russia and the Caucasus:—(1) Forests or coppices arresting movable sands; (2) protecting the banks of rivers or other waters; (3) growing in any quantity on mountains, hills, precipices, and slopes, if such trees or shrubs prevent the falling of earth or rock; and (4) protecting the upper reaches of and sources of rivers and their tributaries. Destructive felling of trees, and the pasturing of cattle in young woods, or in clearings, are forbidden. Land irregularly cleared of timber must be replanted by the owner, and so forth. For the purpose of carrying out these laws, a Forest Preservation Committee exists in each province, presided over by the Governor, and composed of representatives of the nobility, of the administration of the law courts, of the zemstvo, and the owners of woods and forests. Down to the 1st January, 1895, there were 36,000,000 dessiatines (97,000,000 acres) of forest under the supervision of these committees, including 7,000,000 dessiatines (19,000,000 acres) of peasant land, and 19,000,000 dessiatines (51,000,000 acres) belonging to

private owners; in the total there were 890,000 dessiatines (2,403,000 acres) of forest recognised as protected, and the plans of arrangement of 4,166,000 dessiatines (11,238,000 acres) of unprotected forest had been sanctioned by the Government. There are tracts of country, however, almost destitute of forests, and it was declared by scientific authorities that it was impossible to afforest the steppes, but that has been proved not to be the case, as a forest has been created on the steppe in the so-called Great Anadolksy forest. What was formerly a desert, is now covered with 3,000 dessiatines (8,100 acres) of fine forest. Subsequently the work of afforesting was extended to other parts of New Russia, where several other young forests have been created. The Forest Department add about 750 dessiatines (2,025 acres) every year, and the example has been followed by private individuals. It is also worthy of remark that trees have been planted to withstand the shifting sand on the dunes near Libau and Windau, and near the mouth of the Dneiper, close to the town of Aleshky, and in general, measures for arresting the movement of sands in different localities are to be adopted on the widest possible scale. At present the forest authorities, while encouraging the private cultivation of woods and forests, also give out young trees for planting from the existing 31 Government nurseries, and offer prizes for forest cultivation, &c. As regards the forests of Siberia, these all belong to the Government. In Western Siberia alone, the forests are estimated at 110,000,000 dessiatines (297,000,000 acres); in Eastern Siberia the forest area is much greater, but the extent of it is not yet known. As in European Russia, the enormous sylvan wealth of Siberia is very unequally distributed, and in the south there is hardly any wood at all. For a long time the Siberian forests have been free of all supervision and control, and down to the present day the law recognises the right of the denizens of Siberia to the free use of forest timber for all requirements, including the construction of boats. Owing to this attitude, the accumulation of fallen trees and branches, frequent fires, indiscriminate felling of timber, and the pasturing of cattle, &c., have reduced most of these forest properties to a chaotic condition, and in the more populated localities of Siberia there has even come to be a want of wood. It was only in the sixties that regulations were introduced in Western Siberia for the payment of forest fees, but owing to the absence of control, these regulations did not produce much benefit until a forest department and a staff of keepers had been instituted in that region. A great deal of effort is, of course, still necessary to put order into the forest management of Asiatic Russia, and this, it is said, will undoubtedly be facilitated greatly by the growth of population, the increasing demand for timber, and its advance in price.

England, but Russia, owing to its vicinity, has succeeded in introducing considerable quantities into Northern Persia. In all financial and commercial operations an intermediary called a *tellal* must be employed; very long credits are always granted, and it is difficult for a European house to transact business in Persia without a representative. The woollen goods used are generally of inferior quality, and come from Austria and Germany; silk comes from France, Germany and Italy. Most of the silk produced in Persia is consumed locally; the rest goes to Russia, and in small quantities to England. Tea, which may be called the national drink, comes from China and India, and sells at about 2s. per lb. The consumption of sugar is large, and it is imported from France and Russia. There have recently been constructed at Kiserek, about 15 miles from Teheran, an establishment with Belgian capital, the production of which will probably decrease the import of sugar into the country. The importation of arms is prohibited, but the majority of the inhabitants are provided with them; there is much smuggling carried on in these articles, parts of guns being frequently concealed in bales of cotton. In the export trade opium is one of the most important articles. Persian opium is not so highly valued as that from Turkey, owing to the fact that it is frequently adulterated. The opium sent to London is prepared in a different manner from that exported to China. If the roads were better, wool would become a prominent item in the export trade. There are millions of sheep, and the wool is of good quality. Much of it goes to Russia, some to France, or *via* Marseilles to the United States; a certain proportion is used locally in the manufacture of carpets, &c. Cotton grows readily, and during the American Civil War, when there were no exports from that country, the Persian production reached enormous proportions, but it subsequently fell to its ordinary level. There are excellent fruits in Persia, and large quantities are dried for export. The commerce in gum arabic and tragacanth is important. The chief centres for the manufacture of carpets are Santarabad, Korassan, Chiraz, and Kurdistan. In the first named place, one house alone employs more than 10,000 workmen. In the manufacture of carpets a workman receives a little over three half-pence a day, and a carpet worth £8 is sometimes in the hands of three workmen for some six months. The raw materials cost very little, as cotton and wool can be obtained at a very low price in Persia.

Correspondence.

SEWING NEEDLES IN GERMANY.

COMMERCIAL CONDITIONS IN PERSIA.

Cotton goods are the most important articles of commerce in Persia. They are imported chiefly from

Messrs. Henry Milward and Sons, of Redditch, take exception to the statements made by the United States Consul at Annaberg, which were

noticed in the *Journal* of November 5th last (p. 1184), and send the following reply :—

We believe that there was a great depression in the German needle industry some few years ago, but that after the Chino-Japanese war the China market became very active. It must be remembered, however, that the needles used in China and British India are of so low a quality and price that they can only be produced in a country where there is an ample supply of cheap and, presumably, inferior labour, such as is not to be found in England. This disposes, by the admission of the Consul, of about 70 per cent. of the whole German trade. Again, the Consul speaks of the infant industry of a few years ago, and of German needles now finding their way into the English market. The industry is one of the oldest in the world, and was introduced from Germany into England, the oldest manufactories now existing in each country claiming equal date, while, if it be true that a very few cheap German needles find their way into England, a larger quantity of the best English needles are sold in Germany. The great civilised markets of the world are held by the English manufactories, and the greatest and best-equipped manufactories are to be found here. We acknowledge with regret the superior advantages for acquiring technical knowledge, &c., enjoyed by the German foremen and artisans, which is only partially compensated by the superior grit of the English workmen, and we long for the time when the nation will direct the expenditure of the money now allotted to County Councils for technical education, and, with a definite aim, erect, equip, and maintain the technical schools which are to be found throughout Germany.

Obituary.

JOHN OLDFIELD CHADWICK, F.C.A.—Mr. Chadwick, who had held the offices of Auditor of the Society of Arts since 1875 and of Examiner in Book-keeping since 1883, died at his residence at Hampstead on the 12th of November last, after a short illness. Mr. Chadwick was born at Macclesfield, Cheshire, in 1835, and spent the earlier portion of his life at his native place, where he was educated previously to his attendance at St. Mark's College, Battersea. He was one of the early members of the Institute of Chartered Accountants, and took an active part in its proceedings. He was elected a member of the Society of Arts in 1872, and was intimately associated with the Society from the time he became its professional auditor. He was much interested in questions of archaeology and political economy, and filled the office of Vice-President of the Royal Statistical Society at the time of his death.

General Notes.

PAINTERS' COMPANY.—The Worshipful Company of Painters offer a Travelling Studentship of £50 for the encouragement of the study of decorative painting. The studentship is open to competition by students between the ages of 20 and 35, in any recognised school of art or other institution devoted to the study of applied art in any form, and situate within the limit of the larger metropolitan postal area. Copies of the rules for the competition may be obtained from the clerks of the company, Painters' Hall, Little Trinity-lane, E.C., on or before the 10th of December. All the drawings sent in for the competition must be delivered at Painters' Hall on or before 1st March, 1898.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

DECEMBER 8.—“The Mining and Metallurgical Industries of Sweden, as shown at the Stockholm Exhibition of 1897.” By BENNETT H. BROUGH. The RIGHT HON. SIR BERNHARD SAMUELSON, Bart., F.R.S., will preside.

DECEMBER 15.—“The Purification of Sewage by Bacteria.” By SAMUEL RIDEAL, D.Sc. SIR DOUGLAS GALTON, K.C.B., F.R.S., will preside.

Papers for meetings after Christmas :—

“The Protection of Industrial Property.” By J. F. ISELIN.

“The Projection of Luminous Objects in Space.” By ERIC BRUCE, M.A.

“Aeronautics.” By CAPTAIN B. BADEN-POWELL.

“Stage Mechanism.” By EDWIN O. SACHS.

“The Recent History of Papermaking.” By CLAYTON BEADLE.

“The Preparation of Meat Extracts.” By C. R. VALENTINE.

“Children's Sight.” By R. BRUDENELL CARTER, F.R.C.S.

“Fireproof Construction of Domestic Buildings.” By THOMAS POTTER.

“Compensation to Workmen.” By A. D. PROVAND, M.P.

“The Production of Low Temperatures.” By Dr. CARL LINDE.

“The Cinematograph.” By JULES FUERST.

“The Present Condition of the Sugar Industry.” By T. R. TURNELL.

INDIAN SECTION.

The meetings of this Section will take place on the following Thursdays, at 4.30 or 8 o'clock :—

January 20, February 17, March 10, 31, April 28, May 19.

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesday afternoons at 4.30 o'clock:—

January 18, February 15, March 15, April 5.

APPLIED ART SECTION.

The meetings of this Section will take place on the following Tuesday evenings, at 8 o'clock:—

January 25, February 22, March 8, 29, April 26, May 17.

CANTOR LECTURES.

The following courses of Cantor lectures will be delivered on Monday evenings, at Eight o'clock:—

Dr. EUGENE F. A. OFACH, F.I.C., F.C.S., M.I.E.E., "Gutta Percha." Three Lectures.

LECTURE II.—DECEMBER 6.

The Cleaning Processes.—Mechanical cleaning process—Loss during mechanical cleaning—Chemical washing process—Chemical hardening process—Extraction from raw material and from leaves by means of solvents—Advantages and disadvantages of the different processes—Natural substitutes for gutta percha.

LECTURE III.—DECEMBER 13.

The Clean Material.—Chemical composition, mechanical and electrical properties—Application for various technical purposes—Use of hardened gutta percha for golf balls—Absorption of oxygen and behaviour towards ozone—Deterioration and preservation—Artificial substitutes for gutta percha—Concluding remarks.

CYRIL DAVENPORT, "Decorative Book-binding." Three Lectures.

January 24, 31, February 7.

HUGH STANNUS, "The Principles of Design in Form." Four Lectures.

February 14, 21, 28, March 7.

PROF. W. NOEL HARTLEY, F.R.S., "The Thermo-Chemistry of the Bessemer Process." Three Lectures.

March 14, 21, 28.

DR. D. MORRIS, C.M.G., "India Rubber." Two Lectures.

April 18, 25.

PROF. CARUS WILSON, "Electric Traction." Four Lectures.

May 2, 9, 16, 23.

JUVENILE LECTURES.

Two Lectures, suitable for a Juvenile audience, will be delivered on Wednesday evenings, the 5th and 12th of January, at Seven p.m., by WILLIAM RAMSAY, Ph.D., F.R.S., on "Fire."

MEETINGS FOR THE ENSUING WEEK.

- MONDAY, DEC. 6... SOCIETY OF ARTS, John-street Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr Eugene F. A. Obach, "Gutta Percha." (Lecture II.—"The Cleaning Processes.")
Farmers' Club, Salisbury-square Hotel, Fleet-street, E.C. 4 p.m. Mr. Reid, "British Agriculture under Free Trade, 1846-1896."
Engineers, in the Theatre of the United Service Institution, Whitehall, S.W., 7½ p.m. Reginald E. Middleton, "The Pollution of Water and its Correction."
Chemical Industry (London Section), Burlington-house, W., 8 p.m. Mr. H. L. Sulman and Dr. F. Teed, "The Sulman-Teed Process of Gold Extraction."
Imperial Institute, South Kensington, 8½ p.m. Mr A. J. McMillan, "The Mineral Resources of British Columbia and the Yukon."
Surveyors, Savoy-street, W.C., 8 p.m. Mr. F. Punchard, "Royal Commissioners' Suggested Amendments to the Agricultural Holdings Act, 1883."
Geographical, University of London, Burlington gardens, W., 8½ p.m. Lieutenant R. E. Peary, "Explorations in the North of Greenland."
Camera Club, Charing-cross-road, W.C., 8½ p.m. Exhibition of slides of Devonshire.
Victoria Institute, 8, Adelphi-terrace, W.C., 8 p.m. Dr. Lansdell, "Ancient Tithe-giving."
London Institution, Finsbury-circus, E.C., 5 p.m. Mr. Henry W. Lucy, "Parliaments of the Queen."
- TUESDAY, DEC. 7... Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on papers by Messrs. Hugh L. Callendar and John T. Nicholson, "The Law of Condensation of Steam."
Pathological, 20, Hanover-square, W., 8½ p.m.
Anthropological, 3, Hanover-square, W., 8½ p.m.
Biblical Archaeology, 37, Great Russell-street, W.C., 8 p.m.
Colonial Inst., Whitehall-rooms, Whitehall-place, S.W., 8 p.m. Mr. W. Saville-Kent, "Australian Natural History Gleanings."
- WEDNESDAY, DEC. 8... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Bennett H. Brough, "The Mining and Metallurgical Industries of Sweden as shown at the Stockholm Exhibition of 1897."
Royal Literary Fund, 7, Adelphi-terrace, W.C., 3 p.m.
Royal Society of Literature, 20, Hanover-square, W., 8½ p.m. Mr. Charles Welch, "London Civic Ceremonial: Past and Present."
- THURSDAY, DEC. 9... Royal, Burlington-house, W., 4½ p.m.
Antiquaries, Burlington-house, W., 8½ p.m.
London Institution, Finsbury-circus, E.C., 6 p.m. Prof. W. Boyd Dawkins, "The Frontier of History in Britain."
Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Annual Meeting.
Mathematical, 22, Albemarle-street, W., 8 p.m.
- FRIDAY, DEC. 10... Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. Grote Stirling, "Permanent Way: its Construction and Relaying."
Astronomical, Burlington-house, 8 p.m.
Junior Engineering, Westminster Palace Hotel, S.W., 8 p.m. Mr. Basil H. Joy, "Main Engine Auxiliaries in the Mercantile Marine."
Clinical, 20, Hanover-square, W., 8½ p.m.
Physical, Chemical Society's Rooms, Burlington-house, W., 5 p.m.
- SATURDAY, DEC. 11... Botanic, Inner Circle, Regent's-park, N.W., 3¼ p.m.

Journal of the Society of Arts.

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FRIDAY, DECEMBER 10, 1897.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****JUVENILE LECTURES.**

The usual short course of lectures adapted for a juvenile audience will be given on Wednesday evenings, January 5 and 12, 1898, by Professor WILLIAM RAMSAY, Ph.D., F.R.S., on "Fire."

The lectures will commence at 7 o'clock. Special tickets are required for these lectures, which can be obtained on application to the Secretary. A sufficient number of tickets to fill the room will be issued to members in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each member is entitled to a ticket admitting two children and an adult. Early application should be made.

CANTOR LECTURES.

Dr. EUGENE OBACH, F.C.S., delivered the second lecture of his course on "Gutta Serena," on Monday evening, December 6.

The lectures will be printed in the *Journal* during the Christmas recess.

Proceedings of the Society.**FOURTH ORDINARY MEETING.**

Wednesday, December 8, 1897; The Right Hon. Sir BERNHARD SAMUELSON, Bart., F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Hilditch, James Bracebridge, Asgill-house, Richmond, Surrey.

Wattenbach, Oscar, 15, Long-lane, E.C.

Welton, William Shakespeare, 46, Canfield-gardens, N.W.

The following candidates were balloted for and duly elected Members of the Society:—

Davies, W. J., Tupsley-lodge, Hereford.

Gandil, Viggo, care of Messrs. Bewicke and Wulffsohn, Vancouver, British Columbia.

Maitland, Major-Gen. Pelham James, C.B., United Service Club, Simla, India.

Sutherland, Sir Thomas, G.C.M.G., LL.D., M.P., 4, Buckingham-gate, S.W.

Webster, John J., 39, Victoria-street, S.W.

Wells, Henry Hallifax, 16, Paternoster-row, E.C.

Wells, William James, Beechurst, Kingswood, Reigate, Surrey.

Wilson, John William, Drewton Stray, South Cave, Yorkshire.

The paper read was—

THE MINING AND METALLURGICAL INDUSTRIES OF SWEDEN AS SHOWN AT THE STOCKHOLM EXHIBITION.

By BENNETT H. BROUGH,
Assoc. R.S.M., F.I.C., F.G.S.

A whole generation has passed since an exhibition was held in Sweden, the first Scandinavian Exhibition having taken place at Stockholm in 1866. Since that date the necessity which every civilised country is under to keep pace with the progress made by the rest of the world led to the expression of a general wish for an exhibition on a large scale which should show the resources of the country and the present state of science and art in Sweden—in short, for an essentially national exhibition to be held at Stockholm in the 25th year of the reign of King Oscar II. On December 16, 1893, the leading societies and works' proprietors approached the King with a petition giving an expression to the popular wish; and, the suggestion meeting with royal approval, a commission was appointed on April 27, 1894, under the presidency of H.R.H. the Crown Prince, to consider the preliminary arrangements. The commission carried on its work in two sections—one under the chairmanship of H.R.H. Prince Eugene, dealing with the Fine Arts; and the other, under the chairmanship of Baron Tamm, dealing with Industry. The Fine Art Section was international, but exhibits in the Industrial Section, were confined to Scandinavia (Sweden, Norway, Denmark, and Finland). The exhibition was opened on May 15, and closed on October 1. The industrial exhibits were divided into nine sections:—1. Education; 2. Home Industries; 3. Civil Engineering and Architecture; 4. Manufactures; 5. Machines; 6. Navigation and Fisheries; 7. Electricity; 8. Naval and Military; 9. Sport and Travel.

The site chosen for the Exhibition was the best imaginable on account of its natural beauties and of its being easily accessible. For intrinsic picturesqueness and natural beauty of situation the capital of Sweden is unsurpassed by any other city. Built partly upon eight islands, at the confluence of the fresh waters of Lake Mälär, with the salt waters of the Baltic, it possesses romantic features not to be met with in other capitals. The Exhibition buildings were placed on the narrow tongue of land, on which is situated

carrying passengers to and from the islands and the mainland. The grounds covered an area of 228,800 square yards, or taking in the Skansen gardens which were accessible to visitors without extra charge, the total area exceeded 440,000 square yards.

The most important of the hundred buildings comprising the Exhibition was the Industrial Hall (Fig. 1), designed by Mr. F. Boberg, the architect whose originality and good taste was well shown in so many of the smaller buildings. This covered an area of over 16,500 square

FIG. 1.



Industrial Hall at the Stockholm Exhibition.

the beautiful deer park (Djurgården), Stockholm's pride and pleasure-resort, in full view of the bridge leading to the city. The Exhibition grounds were bounded on the east by the narrow waters of the Djurgårdsbrunnsvik, on the west by the harbour of Stockholm, and on the south by the steep richly-wooded hill, where the unique botanical and zoological gardens of Skansen represent in an enclosure of 40 acres a miniature Sweden. The Exhibition was easily reached by numerous tramways and by the small steamboats constantly

yards. The massive dome, which like the rest of the hall was painted in brilliant colours, rose to a height of 320 feet. Round the dome were four minarets, in which staircases and elevators gave access to a balcony whence a magnificent view could be obtained of the Exhibition buildings, of the city of Stockholm, and of its thickly wooded environs. The Industrial Hall was, I believe, the largest wooden edifice ever built. Picturesquely surrounded by the other buildings, it formed the centre of a striking panorama in which were

noticeable the handsome administrative offices, the Northern Museum, the Fishery Court, the Fairy Grotto, the Horseshoe Restaurant, the Chemical Industrial Hall, the section of Sport and Travel, the Fine Arts Court with an imposing equestrian statue of King Carl Gustavus, and the quaint reproduction of old Stockholm in the year 1500, whilst high in the air was an overhead wire ropeway carrying visitors across the water to the Exhibition.

For the foreigner weary of world's fairs, the great charm of the Stockholm Exhibition was the absence of a "Midway Plaisance," of cafés chantants, of side-shows, of Hungarian bands, in short of the inevitable catch-penny recreative department. It afforded a welcome return to the traditions of the Great Exhibition of 1851. Systematically arranged with descriptive labels and fully described in the excellent catalogues and guide-books available, the exhibits gave a clearer idea of the resources of the country than could be obtained by years of travel and exploration, and in no section was this more patent than in that of mining and metallurgy.

I. THE MINING EXHIBITS.

Among the mining countries of the world, Sweden occupies a prominent position. Its mineral deposits cover a vast area; its mines have been worked without interruption since prehistoric times, and its iron has long been world-famed for its purity and excellence. It was, therefore, to be expected that in a Swedish exhibition, the exhibits relating to mining would be of the greatest interest, and at Stockholm they justly occupied a prominent position. Seeing that the central committee of the Exhibition included the names of such eminent metallurgists as Baron C. G. A. Tamm; A. H. Göransson, of Sandviken; C. C. Linberg of Laxå; E. J. Ljungberg, of Falun; K. Söderblom, of Eskilstuna; G. W. S. Tham, of Husqvarna; R. Åkerman, the Director of the Swedish Board of Trade; and H. Lundbohm, the geologist, it was not surprising to find that the exhibits had obviously been chosen with unusual judgment.*

* For most of the information given I am indebted to the exhaustive and authoritative literature available in the "Officiel Katalog öfver Industriafdelningen," and the "Officiel Vägvisare," published by the exhibition authorities, the catalogue of the central Swedish mining exhibit, by Professor Nordenström, the same author's account of the mining industry, published by the Jernkontor, and the official mineral statistics, compiled by the General Director, R. Åkerman, of the Swedish Board of Trade. I am also under great obligations for valuable verbal explanations to Professor Nordenström, to Professor Wiborgh, to Mr. J. C. Kjellberg, to Captain Herlenius, and to several other gentlemen whose names are mentioned in the paper.

Some of the leading ironworks had their exhibits arranged in pavilions of their own. Many were placed in the great Industrial Hall, but the collective exhibit from the mines of the central iron ore district of Sweden was shown in two red-painted buildings, one having the shape of a shaft head gear, and the other of a mine dressing floor. From the second floor of the latter proceeded an aerial wire ropeway to the adjoining hill of Skansen, in which a short tunnel had been blasted in order to afford visitors an opportunity of seeing an electric rock-drill at work. The shaft-tower had an area at the base of 75 square yards, and a height of 82 ft., while the dressing floor was 82 ft. long and 33 ft. wide.

The development of the mineral resources of Sweden has been much facilitated by the fact that the country is well supplied with railways, the greater portion of the lines serving the mining districts, and permitting the ores to be transported in all directions. Although there were, in 1856, not more than forty-one miles of railways for locomotives, at the present time no other country in Europe has so great a length of railway per inhabitant. This is shown in the following Table, which (on the authority of the *Journal Officiel*, of October 28, 1897) gives the number of miles of railway per 10,000 inhabitants on January 1, 1897:—

	Miles.		Miles.
Sweden ..	12.5	Holland and	
Switzerland ..	7.4	Luxemburg }	3.8
France ..	6.6	Roumania ..	3.3
Denmark ..	6.1	Italy ..	3.0
Norway ..	6.0	Portugal ..	2.8
Germany ..	5.6	Greece ..	2.7
Belgium ..	5.6	Russia ..	2.3
United Kingdom	5.4	Servia ..	2.3
Austria Hungary	4.5	Turkey ..	1.7
Spain ..	4.2		

At the present time Sweden possesses 6,154 miles of railway.

The geological structure of Sweden was clearly elucidated by the complete collection of geological maps and specimens exhibited in a large hall by the Geological Survey (Sveriges geologiska undersökning), a Government institution, founded in 1858. This exhibit formed one of the most instructive mineralogical collections ever brought together. From the maps shown it was evident that a large portion of the surface of Sweden is composed of crystalline rocks, such as granite, gneiss, porphyry, granulite, and hälleflinta (petrosilex). In the two last the most important metalliferous deposits occur. The crystalline Primary rocks

are, as a rule, covered by beds of Quaternary age. The intermediate formations occupy a restricted area, and, of these, rocks of Silurian age have the greatest extension.

Among the various minerals met with, Sweden is chiefly remarkable for its excellent iron ores. Other minerals occur in much smaller quantities, the most important being the ores of copper and zinc; then follow in order silver ores, lead, manganese, nickel pyrites, and last cobalt ores and graphite. In the south of Sweden, where Jurassic rocks are met with, beds of coal occur and are worked on a fairly large scale.

Iron Ore Deposits.

The Swedish iron ores occur chiefly in three forms:—

- (1.) Magnetite, often containing as much as 6 to 10 per cent. of manganese. Phosphorus is usually absent, but frequently the ore is associated with iron pyrites. The deposits occur in crystalline rocks in lenticular beds parallel to the enclosing strata.
- (2.) Red hæmatite, as hard and massive specular iron ore, in veins in quartzite and granite.
- (3.) Brown iron ore of recent age extending over the bottom of lakes or occurring as bog iron ore. Last year in Sweden 925 tons of these ores were collected.

Of the mines working iron ore containing very little phosphorus, the following may be selected as typical examples from among the many mines exhibiting specimens, plans, photographs, and models.

1. In the metalliferous district of Kopparberg and Westmanland, a district noted for the rich copper deposit at Falun, well arranged exhibits were shown by Bisberg and Norberg mines. The former has been worked for more than 500 years, a charter relating to these mines, dated the 22nd March, 1388, being known to exist. The ore worked contains 70·7 per cent. of iron and 0·0045 per cent. of phosphorus. The output last year amounted to 13,071 tons. The Norberg mines were worked at a still earlier date, the oldest document relating to the mines dating back to 1303. The oldest charter was shown at the Exhibition; it was signed in 1354 by King Magnus Eriksson. The magnitude of the mines at the present time is shown by the fact that last year 58,500 lbs. of high explosives were consumed, the output of red hæmatite amounting to 6,771 tons.

2. In the province of Wermland, the chief mines exhibiting included the mines of the Persberg Company which, having been worked since 1360, produced last year 27,100 tons of magnetic iron ore; the Taberg mines, which produced last year 7,555 tons of magnetic iron ore containing 54·36 per cent. of iron and 0·008 per cent. of phosphorus; and the Långban mines, which produced last year 1,267 tons of magnetite, 4,500 tons of hæmatite, and 1,564 tons of rich manganese ores.

3. In the province of Upsala are situated the far-famed Dannemora mines, where the beds of magnetic iron ore have a characteristic lenticular shape, and form a huge deposit which has been worked since 1481 along the outcrop for a distance of more than a mile. In the middle the deposit is more than 180 ft. in thickness. The annual output of the mines amounts to 55,000 tons; six steam-engines of 218 horse-power, and four turbines of 136 horse-power being used for winding and pumping. Here, in 1805, the first steam-engine for pumping was used in Sweden.

4. In 1886 I had an opportunity of studying a deposit of great geological interest, not shown at the Exhibition, as mining is not now being carried on, namely, that of the Taberg, near Jönköping, not to be confused with the Taberg mines in Wermland. This forms a hill rising 400 ft. above the surrounding gneiss. The entire mountain consists of a granular crystalline mixture of magnetite and olivine, but as it does not contain more than 31 per cent. of iron, it cannot at the present time be worked at a profit. The deposit is one of great magnitude, and it is to be hoped that eventually some economical method of concentrating the ore will be found.

5. Of the deposits of iron ore rich in phosphorus, those worked at Grängesberg in the province of Kopparberg were well illustrated at the Exhibition. The mines, now the most productive in the country, have been worked, more or less, since 1600, but owing to the high percentage of phosphorus, and to the demand for pig iron free from phosphorus, little was done till the invention of the Thomas and Gilchrist process of steel making rendered it possible to utilise these ores. Since 1882 there has been a large export trade in them to Germany and Austria. This is well shown by the following figures, copied from a graphic diagram exhibited:—

Year.		Output. Tons.		Exports. Tons.
1882	....	48,000	....	—
1884	....	70,000	....	20,000
1890	....	172,000	....	130,000
1891	....	222,000	....	135,000
1892	....	270,000	....	175,000
1893	....	285,000	....	205,000
1894	....	425,000	....	320,000
1895	....	590,000	....	370,000
1896	....	639,000	....	550,000

The ores mined exist in three parallel lines of large lenticular bodies extending for three and a quarter miles. The surrounding rock consists of granulite. The proportion of iron in the ore exported varies from 61 to 63 per cent. It is shipped from Oxelsösund. The mines are worked largely by quarrying, and the nature of the operations was well shown in a fine painting exhibited by Mr. A. Jungstedt. Most of the machinery is worked by electric power, and the installation was the first long distance transmission of power in Sweden, the distance from the turbines at the Hellsjö lake to Grängesberg being $7\frac{1}{4}$ miles. Dynamite is used for blasting, and is manufactured on the spot.

6. The remarkable deposits of Gellivare, Luossavaara, Kiirunavaara, are exceedingly rich, but owing to their geographical position (lat. $67^{\circ} 20' N.$) have only since 1892 become of practical importance. They were well represented at the Exhibition by numerous specimens of ore, mine plans, a geological model of the Gellivare iron mountain, and a large oil painting of Kiirunavaara and Luossavaara. The Gellivare deposits are four to five miles long, by one to two miles broad, and are of enormous thickness. They occur in red gneiss, and consist of magnetite. The ores are of two kinds, one with a guaranteed maximum of phosphorus, and the other with a guaranteed minimum, the former being due to an admixture of apatite. They are classified into the following five grades:—

	Iron. Per cent.		Phosphorus Per cent.
A.	68.69	..	0.05
B.	67.68	..	0.1
C.	65.67	..	0.8
D.	63.64	..	0.7
E.	60.00	..	1.5

The last is not exported.

The production of the Gellivare mines last year amounted to 604,357 tons of magnetic iron ore, and it is estimated that there is

enough ore above the surface level to last for 200 years.

On the way to Victoriahavn, on the always accessible west coast of Norway, the projected railway from Gellivare passes the deposits of Kiirunavaara and Luossavaara. These are similar in character to those at Gellivare. The similar deposit of Svappavara also contains a large amount of ore, but being off the railway route can be regarded only as a reserve.

In 1896, the iron ore shipped from Luleå amounted to 625,795 tons, compared with 384,007 tons in the previous year. The greater portion, 448,315 tons, was taken by Germany. Great Britain followed with 91,400 tons, Belgium with 62,350 tons, and France with 21,550 tons.

When the new railway to the Norwegian coast is completed, large ironworks will probably be built on the Norwegian side. There are some 2,000 miners employed at Gellivare, the majority earning 4s. a day. The Gellivare deposits have been fully described by Mr. Jeremiah Head.*

From the 338 iron mines in operation in Sweden last year, there was raised 3,646,114 tons of material, from which was obtained 1,780,903 tons of dressed magnetite and 257,191 tons of red hæmatite, making a total production of 2,038,094 tons. It is curious to note that in 1870, when David Forbes wrote his paper† on the iron ores of Central Sweden, the total production was only 630,000 tons.

Other Metalliferous Deposits.

Let us turn now to the ores of other metals.

The Swedish copper ores are composed in almost all cases of copper pyrites mixed, more or less, with iron pyrites, magnetic pyrites, zinc-blende, galena, amphibole, and quartz. The mean proportion of copper varies as a rule from 2 to 5 per cent. The copper mine of the greatest interest is that of Falun, the most ancient and most extensive mine in Sweden, models and photographs of which were well represented in the magnificent collection exhibiting the resources of the Stora Kopparberg Mining Company, the owners of the mine. The deposit, which has been worked for nearly 700 years, originally as an open quarry, is in many respects similar to the Rio Tinto deposit. The lenticular masses

* "Journal of the Iron and Steel Institute," 1895, No. ii (p. 364.)

† *Ibid*, 1871; p. 469.

of ore extend over an area $4\frac{1}{2}$ miles long and $2\frac{1}{2}$ miles wide. The mine produced last year 15,654 tons of copper pyrites. Two varieties of ore are raised, hard and soft. The former consists of quartz with interspersed copper pyrites. Up to the beginning of the 18th century mining was carried on by fire setting, and the annual consumption of wood for this purpose rose to more than 2,000,000 cub. ft. Several times the masses of timbering caught fire, and the mine caved in. The old methods of working gave rise to such disasters in 1687, 1833, and 1876; the most serious was that of 1687, which formed a huge chasm 1,180 ft. long, 600 ft. broad, and 285 ft. deep. Improved methods of working to obviate the recurrence of such catastrophes were introduced in 1877. Accurate statistics of production have been kept since a very remote period. These show that the total output of the mine represents a value of more than £55,500,000 sterling. The greatest production was obtained in 1651, when the amount of metallic copper made was 3,066 tons, and the lowest in 1833, when the production was 338 tons. At the present time the copper is usually sold in the form of copper vitriol, of which 1,506,398 tons were made last year. Besides this, the works produced 300 tons of sulphate of iron, 2,000 tons of sulphuric acid, 1,000 tons of red ochre, 300 kgs. of silver, and 100 kgs. of gold.

The red ochre referred to is obtained by calcining the products of the weathering of the iron pyrites. It is used throughout Sweden for painting the farmhouses, cottages, and mine buildings, and is so general that it forms a characteristic feature of Swedish scenery.

The mine at Falun is 1,200 feet deep, and its underground roadways have a total length of about 18 miles.

Of zinc mines the most important are those of Ämmeberg, bought in 1857 by the Vieille Montagne Company. They produced last year 16,332 tons of zinc ore, and 572 tons of silver lead ore. The deposits consist of beds of zinc blende in gneiss. Of silver lead mines the most important are the ancient mines of Sala where argentiferous galena occurs in lenticular masses in limestone. These mines produced last year 4,745 tons. Among the objects of historical interest exhibited in connection with them were the mine bucket in which King Carl XI. descended the mine on August 13th, 1687, and a section of the mine drawn by Olof Trygg in 1639. Other plans of the mines which were exhibited by the Royal Board of Trade, dated from 1642 and 1662.

The production of ores of metals, other than iron, from the 84 Swedish mines last year, was as follows:—

Ores.	Quantity (tons).	Value (£.)
Gold	736	1,278
Silver and Lead	15,381	16,258
Copper	24,351	17,961
Zinc	44,041	71,455
Manganese	2,056	1,566
Iron Pyrites	1,009	630

Coal.

The coalfield of Scania, in the extreme southern portion of the kingdom, is of Jurassic age, and consists of alternating beds of sandstone, shale, clay and coal, the total thickness of the coalseams not exceeding 5 ft., of which not more than 1 ft. 6 in. consists of coal, while the remainder is shale. Immediately below the coalseams there is a fireclay bed of excellent quality, which is worked with the coal. The seams are horizontal or but slightly inclined. The height from roof to floor varies between 3 ft. and $5\frac{1}{2}$ ft., while the roof generally consists of fairly solid sandstone. In the Höganäs colliery the seam is first holed in a bed of soft shale to a depth of a yard and for a length of about four yards. The coal above the undercut, except that of best quality which is kept up provisionally by props, is then brought down by wedges and picks; and, when the work has been pursued in this manner as far as local circumstances permit, the best coal is brought down in large lumps. Lastly, the underclay is taken out by means of wedges and picks. Of the three clay beds, which are directly superposed in this colliery, the upper is always taken out, and the second if required, but rarely the third. Explosives are only used for sinking shafts and driving stone-drifts, although firedamp has never been met with in Scanian collieries. Only two colliery companies exhibited, the Billesholm-Bjufs Company, and the Höganäs Company. The latter celebrated on September 4th last, the 100th anniversary of its existence.

The development of the Swedish coal-mining industry is well shown by the following statistics of production:—

Year.	Tons.
1860	26,476
1870	36,727
1880	100,875
1890	187,512
1895	223,652
1896	225,848

Last year the output of the various collieries was as follows:—

Colliery.	Shafts.	Coal.	Fireclay.
		Tons.	Tons.
Skromberga	2	46,336	217
Boserup	1	1,735	—
Höganäs	2	52,742	35,991
Billesholm	3	76,615	36,482
Ljungsgårda	1	2,512	4,540
Bjuf	2	45,809	33,692
Stabbarp	1	99	9,504
Total	12	225,848	120,426

Depth of Mines.

With regard to the persistency of the deposits in depth, it may be noted that some of the copper mines have been worked to a depth of more than 1,300 feet. Thus the Atvidaberg copper mines have a vertical depth of 1,350 feet. These are the deepest mines in Sweden. The Sala silver lead mines have a depth of 1,050 feet. Of the iron mines those of Taberg in Wermland and of Dalkarlsberg have a depth of 1,170 feet and 1,080 feet respectively. Other deposits, even those worked from time immemorial are not nearly so deep. The amount of ore available is well shown by the following figures giving the areas of the horizontal sections of the various deposits:—

Mines.	Area of Horizontal Section of iron ore.	Percentage of iron.
	Square yards.	
Kirunnaavaara-Luossavaara	600,000	61 to 72
Routivare	360,000	50·27
Taberg (Småland)	312,000	31·45
Gellivare	240,000	61·30
Grängesberg	108,000	62·80
Svappavaara	45,600	50 to 73
Norberg	36,000	59·44
Dannemora	14,400	57·46
Striberg	11,040	60·76
Persberg	8,520	61·78
Stripa	7,200	45·00
Kanntorp	7,200	62·70
Nordmark	6,000	59·70
Stråssa	5,640	53·20
Pershyttan	3,840	42·67
Finnmosen	3,480	82·30
Dalkarlsberg	3,444	61·80
Sköttgrufvan	3,336	56·80
Bispsberg	2,400	70·70
Other mines	74,700	—
Total	1,852,800	—

All these deposits deviate but slightly from the vertical, the areas given afford a fairly accurate idea of their magnitude.

Methods of Working.

The ores of most frequent occurrence in Sweden, those of magnetic iron, are always more or less polar. Indeed, the red hæmatites are almost always sufficiently mixed with magnetite to attract the magnetic needle. For this reason explorations for iron ore are invariably made with a compass, specially constructed for the purpose. This instrument, invented in the last century by the celebrated Swedish miner, Daniel Tilas, consists of a circular brass box, in which a magnetic needle is horizontally suspended on a long vertical brass pin, by means of a long glass cap. The brass terminates above in a short steel point on which the cap rotates. At the bottom of this is a brass stirrup, provided with fine holes, through which pass the horizontal pins supporting the needle. To enable the needle to dip, there is a long slot cut along the middle of it. Thus the needle can move both in a horizontal and in a vertical plane; and it is balanced in such a way that it takes a horizontal position when acted on by terrestrial magnetism alone. In using this instrument for prospecting purposes, it is necessary to observe merely the dip of the needle. In this way it is easy to ascertain the existence of attractive iron ore, and the approximate extent of the deposits, even when they are covered by other strata or by water. When the lakes are frozen over in winter, prospecting in this way is easy.

Nearly all the Swedish deposits have been discovered by the aid of this simple instrument, and it is still in general use for preliminary surveys. Of late years, however, more delicate magnetic instruments have been introduced for obtaining more exact information regarding the magnetic conditions of the iron ore deposits. These are Thalén's magnetometer, and Tiber's inclination balance, particulars of which it was my privilege to bring before the notice of English readers in a paper read ten years ago.* At Stockholm the magnetometric collection arranged by Professor Nordenström, who is second to none in his skill in the application of these methods, was one of the most striking exhibits ever got together. On a glass table on which the plan of a deposit was

* "Use of the Magnetic Needle in Exploring for Iron Ore," *Journal of the Iron and Steel Institute*, 1887, p. 280. See also B. H. Brough's "Treatise on Mine Surveying," 6th edition, 1897, p. 296.

drawn, and under which was placed an old propeller blade representing the deposit, the various instruments were placed and their use demonstrated. There was also a complete collection of ancient and modern mining compasses, and of magnetic plans. The latter included that drawn by F. von Scheele in 1832, the oldest magnetic mine plan extant, whilst among the modern magnetic plans was one drawn last year from surveys made by Mr. Johansson, a pupil of Professor Nordenström's, at Pedroso mine in Andalusia, belonging to the Iberian Iron Ore Company. This affords conclusive evidence that the modern Swedish methods can be successfully applied in more southern latitudes,

With the modern improved instruments properly used, trustworthy results cannot fail to be obtained. With the old dip compass, however, they are possible only when the observer is acquainted, by long experience, with the peculiarities of his instrument. There is a strong temptation for a skilful operator to keep his mode of procedure secret. Consequently the uninitiated are apt to believe that he must be specially gifted, and frequently the supernatural properties ascribed to the divining rod are transferred to the compass. The compass is unfortunately well adapted for dishonest purposes. A case is recorded in which a compass needle in the vicinity of ore always showed a dip of 90° when facing west, and the true dip due to local attraction when facing east. The former position, it is said, was very successfully used in selling iron ore grounds and the latter in buying them. Similarly a powerful magnet inserted in a walking stick has been employed to give a large dip to the needle when it was thought desirable to mislead the purchaser.

For ascertaining the extent of mineral deposits, since 1886 diamond boring machines worked by hand have been largely and successfully used. All this work has been carried out by the Svenska Diamantborrningsaktiebolag, the extent of whose operations were well shown in their instructive exhibit in the Mining Section at Stockholm. Since 1886 they have bored in the metal mines of Sweden and Norway holes with an aggregate depth of 27,236 yards. Usually the boring machines are worked by hand, but in five cases they have used 2 h.p. oil-gas motors, and in four cases 4 h.p. petroleum motors. An electric motor driven by a 4 h.p. petroleum engine has also been used. Last year the holes bored were as follows:—

Diameter, inches.		No.		Depth, yards.
1'38	....	84	....	3,389'8
2'56	....	11	....	379'1
3'93	....	3	....	132'7
5'31	....	2	....	221'8
100				4,123'4

The cost of diamond boring varies from 10s. 6d. to 12s. 8d. per foot.

In most cases the ore is broken down by hand labour. Owing to the hardness of the rocks and the excellent quality of the drill-steel used, the Swedish miners have acquired great skill, the result being that mechanical drills came into use later than elsewhere. Several mines, however, now use them, the Schram drill and the Rand drill being the types preferred. Recently experiments have also been made with the Siemens and Halske and the Marvin electric drills. Powder is no longer used as an explosive, having been replaced by high explosives. Extra dynamite, patent dynamite, and express dynamite are the names of the explosives preferred. They consist of a mixture of nitroglycerine, nitrated cotton, and ammonium nitrate, the proportion of the last named constituent varying from 25 to 50 per cent. Experience has shown that the amount of rock broken down by 1 lb. of these explosives is from 5 to 7 tons. The character of the explosives was well shown in the exhibit of the Nitroglycerine Company, a company formed in 1864 by Nobel Brothers to work the inventions of Alfred Nobel, for the manufacture of nitroglycerine, and for its employment in blasting operations. Used alone, being liquid, it was difficult to handle. The difficulties were, however, obviated by Nobel's discovery, patented on September 19th, 1867, of absorbing nitroglycerine by kieselguhr, the mixture being called dynamite. The next advance was also due to Nobel, who obtained blasting gelatine by combining guncotton and nitroglycerine. This was patented by him on July 8th, 1876, and is still one of the most powerful explosives known. Extra dynamite is a modification of this.

Originally worked as open cuts, fire being used for breaking the rocks, most of the mines are now worked by underhand stoping. Of late years, however, it has been found necessary to fill the worked-out excavations with rock, and in some cases to work by overhand stopes. The main shafts dating from ancient times are always large and circular, but those sunk recently have a rectangular section. Artificial

ventilation is not required, the natural draught being often so violent in winter that its intensity has to be diminished in order to obviate the formation of ice. For lighting, open lamps or candles are used. At Falun torches of dry wood are also employed for lighting large excavations.

Ore Dressing.

In most of the Swedish iron mines the sterile material is separated from the valuable ore by hand-picking. Of late years magnetic concentrators have, however, been used with advantage, the type of machine preferred being that invented by Mr. Jonas Wenström. This consists of a drum whose sides are provided with several magnets. The drum is composed of a number of isolated iron bars arranged radially, and in such a way that there is always one pair of bars rendered magnetic by one pole of the magnet, while another pair is magnetised by the other pole. Large pieces of ore come in contact with two bars, and are consequently firmly held, and the drum has a slight inclination to allow the non-magnetic material to fall through more readily.

The exhibit of the Hjuljern Mining Company in the province of Örebro, illustrated the arrangements adopted for the magnetic separation of ore at their mines, where the Wenström machine has been in successful use since 1885. For the past three years the daily output of the mine has been screened, and all the material passing through an half-inch hole subjected to magnetic concentration. During this period, 11,613 tons have been screened, yielding 6,077 tons of fine ore, which gave, in the magnetic concentrator, 4,594 tons of ore, and 1,483 tons of waste, or respectively, 75.6 per cent. and 24.4 per cent. of the material treated, the cost being 8½d. per ton of ore separated.

For the grade of Gellivare ores, very rich in phosphorus (*i.e.*, more than 1.5 per cent. up to 3 per cent.), and proportionately poor in iron, a dressing plant has just been erected on the cliff side of the island of Svartö, near the shipping pier at Luleå, for treating 100,000 tons of ore annually. With the ground available the capacity of the plant may be tripled. The ore is taken from bins at the foot of the hill by means of a lift up an inclined plane nearly to the top, where the lumps are broken in stone-breakers; the material thus obtained, mixed with the fine ore, is dried in a rotating cylinder 32 feet long, 4½ feet in diameter, and inclined at an angle of 5°. After drying, the ore is pulverised and subjected to magnetic con-

centration in a Ball and Norton Monarch machine. Two of these, placed one behind the other, yield (i) pure magnetic iron ore, with a high per-centage of iron, and a very low one of phosphorus, and (ii) a mixture of waste rock and apatite. If magnetite were the only valuable product, the low esteem in which powdered ore is held would render the whole process purposeless; notwithstanding that the results of trials made at Domnarfvet with as much as 50 per cent. of powdered ore in the furnace charge, tend to show that less obstacles will be met with in the future in the way of its more general use. Another valuable product is the apatite, which is treated by converting the mixture into a slime by addition of water, from which the large particles are separated for further classification in fine grain jigging machines. The fine slimes are washed after a preliminary sorting on revolving buddles and percussion frames. The pure apatite obtained is dried in a rotating cylinder, 16½ feet long and 3 feet in diameter, and then reduced to an extremely fine state of division, in cement-grinding mills. The powder is then intimately mixed with anhydrous soda, and the mixture heated in a double-hearth reverberatory furnace, and then again finely pulverised, the final product being a highly valuable fertiliser of great solubility, containing 30 per cent. of phosphoric anhydride, and having the same composition as basic slag, that of a tetra-basic phosphate, in which, however, one molecule of the base is formed of soda instead of lime, its formula being $\text{Ca}_3 \text{Na}_2 \text{P}_2 \text{O}_9$. This process is the invention of Professor Wiborgh, the eminent successor of Richard Åkerman, in the Chair of Metallurgy at Stockholm. The extensive installation built this year at Luleå is a conspicuous proof of the energetic manner in which Swedish capitalists are ready to take advantage of an important invention that can be applied to the development of the resources of the country.

Mine Surveying.

The methods of surveying mines in Sweden present many points of interest, and were well exemplified not only by Professor Nordenström's admirable collection of ancient and modern instruments and models, but also by the exhibits of the leading instrument makers. Axel Ljungström, C. E. Rosén, Casselli and Granström. The Swedish mines are surveyed almost exclusively by a graphic method in which a modification of the plane table is employed. This method gives satisfactory results

provided that the survey is not of great extent. In that case recourse is had to the theodolite.

Plans of metal mines, of which an admirable collection had been selected for exhibition, from those preserved by the Royal Board of Trade, have now to be drawn on a scale of 1 to 800, and prepared in accordance with a normal plan fixed by the Government. Contrary to the practice in this country, not more than one plane must be represented on one sheet. In order to give a still clearer idea of the mine, models are constructed. The workings of each horizontal section are shown in oil-colours on superimposed sheets of glass, or owing to the difficulty of clearly seeing through a large number of sheets of glass, the different sections cut out of white cardboard are coloured and fixed on a network of very fine brass wires stretched across superimposed wooden frames. Colliery plans have to be drawn on a scale of 1 to 1,500. Two copies of every mine plan have to be made and revised year by year, one being kept at the mine and the other sent to the Board of Trade at Stockholm.

II.—THE METALLURGICAL EXHIBITS.

As would naturally be expected in the classic home of charcoal pig iron, the exhibits relating to iron and steel were of special interest, owing to the extremely high quality of the products, whether pig iron, wrought iron, or steel. The iron trade was conspicuously well represented, and although most of the exhibits were placed in the Industrial Hall, the largest works, namely, those of the Stora Kopparberg, Sandvik, Bofors and Finspong companies had well designed pavilions of their own.

Stora Kopparberg.

The exhibits of the Stora Kopparberg Company were shown in a separate pavilion of elegant design in a manner fully worthy of the most ancient joint stock company in the world. There is still in existence in the State archives a deed for the transfer of shares in the company dated 1288, and the Royal Charters, which refer to the company as being then very ancient, bear dates from 1347 to 1432. The real estate of the company comprises vast forests, copper and iron mines, and waterfalls representing 100,000 h.p. Dating from its oldest charter, the company celebrated on the 24th February last its 550th anniversary.

Thanks to the foresight of the directors of this great company, it was possible to display

a number of antiquities and relics of the greatest value and interest. Most of them were borrowed from the recently-founded museum of the company, which contains, besides a library of 4,500 volumes and some 20,000 old account books, collections of minerals, of models, and of coins. The mineral collection, of which Mr. Kjellberg's catalogue covers 146 quarto pages, comprises some 10,000 specimens of minerals and the same number of rocks. The models were mostly constructed by Christoffer Polhem, the remarkable mechanical genius of the 17th century, who, as I pointed out in a paper* read in this room a year ago, applied in 1694 the method of hoisting by means of reciprocating rods, like those of the man-engine, and made numerous other important mechanical inventions; amongst others, the Scandinavian padlock, patented in the United States in 1895. The coins, of which a catalogue of 97 pages has been prepared by Mr. Sahlin, were mostly made in the company's works for the Swedish Government from Falun copper. They include many specimens of the characteristic plate coins, a currency possible only in a country in which copper was abundant. The largest of these, a 10 dol. plate, dated 1644, weighed no less than 43½ lbs. Some of the medals, too, are of great local interest. Medals, dated 1735 and 1755, exhibit the methods of mining in vogue at Falun at that epoch. Here, too, was struck in 1747 a medal to commemorate the foundation of the Jernkontor, the Association of Swedish Ironmasters, that has done so much towards maintaining Swedish metallurgy in that high state of efficiency which has so long characterised it.

The exhibits showed the magnitude of the company's trade in timber, iron and copper. From its celebrated copper mine at Falun, to which reference has already been made, the company derives its name of The Great Copper Mountain (Stora Kopparberg). Its first iron-works, Svartnäs, were built in 1735, and some twenty other small works were soon added. Owing to difficulties in manufacturing economically at so many small works, it was decided in 1870 to concentrate the manufacture at Domnarfvet by one of the big waterfalls of the river Dalälven. These new iron-works are the largest in Scandinavia, and the largest iron-works using charcoal fuel in the world. They possess a charcoal burning plant with eight large kilns, a blast-furnace plant with four furnaces, six Westman calcining kilns, and seven Cowper hot-blast stoves, five Bessemer

* *Journal of the Society of Arts*, vol. xlv., p. 64.

converters (two of 6 tons and three of 5 tons), four open-hearth furnaces (each 15 tons), a rolling mill plant, forge, plate-pressing works, and a horseshoe nail factory. Every variety of pure iron and of the highest grade of steel is made, the annual production being 55,000 tons of pig iron, 35,000 tons of Bessemer ingots, 26,000 tons of open-hearth ingots, 7,000 tons of charcoal from blooms, 47,000 tons of rolled and hammered iron and steel of all kinds, and 600 tons of horseshoe nails. The Thomas and Gilchrist basic process was

company being large owners of the phosphoric ores of Grängesberg, as well as of the remarkably pure ores of Norberg, Bispberg, and Stripa.

The excellent quality of the metal was clearly shown by a drinking horn 51 inches long, made from a single plate of Domnarfvet iron (Fig. 2). The original plate had a diameter of 31 in. and a thickness of 0.04 in. Besides this, there were four goblets and a cylinder 21 in. high and 6½ in. in diameter, each pressed out of a single plate.

FIG. 2.



Drinking Horn, 51 inches long, made from a Domnarfvet iron plate, 31 inches in diameter and 0.04 inch thick.

adopted in 1891 for a portion of the outturn, the three 5-ton Bessemer converters and two 15-ton open-hearth furnaces being used for basic work. The iron produced being made, with charcoal, from ores free from phosphorus and sulphur, is of remarkable purity. Indeed, the average per-centage of phosphorus in the Bessemer and open-hearth pig-iron, made during the last three years was only 0.019 per cent. The reason why so many different methods of manufacture are in use is that there is a great diversity of ores available, the

The varied products of the works were skillfully used for decorative trophies of conspicuous artistic merit, whilst the heavier objects displayed comprised huge chiselled castings, and no less than 1,460 sections of rolled iron of every description. As an object-lesson illustrative of the high quality of Domnarfvet tool steel, turning, planing, and boring tools were shown, together with boxes containing the total quantity of shavings and turnings obtained since the last sharpening of the tool. Thus, a turning tool gave 2,336 lbs. of open-

hearth steel shavings, 566 lbs. of cast iron turnings, and 50 lbs. of shavings from a chilled cast iron roll.

In connection with the Domnarfvet exhibit, reference must be made to a very important invention made by Mr. E. J. Ljungberg, the general manager of the company. This is a continuous charcoal kiln, in which the cost of working is only one-third of that of charcoal-burning in heaps. It consists of four or eight chambers. In the first division the wood is decomposed, in the second it is dried, in the third it is preheated, and in the fourth the charcoal is quenched and drawn out and new wood charged in. The combustible gases formed from the decomposition of the wood are burnt in the second section, whilst in the third not less than 30 per cent. of the water in the wood is driven off. For preheating the wood six days are required, for drying and carbonising five days, for the complete carbonisation five days more, and for quenching, drawing and charging four days, making twenty days in all.

A kiln with eight divisions is able to carbonise in the year 6,109·8 cub. ft. of wood in 146 divisions, or 892,112·5 cub. ft., whereby 647,309·6 cub. ft. of charcoal are obtained. Up to the present time not less than ten of these kilns are in use, of which eight are at Domnarfvet, and two at the Skutskär Saw Mills belonging to the company. Fig. 3 shows one of the kilns with eight divisions.

The divisions are numbered 1 to 8. Wood is charged in of the same length as the breadth *a b* of the shaft. Under the floor of each division are two grates, *c* and *d*, one each side of the kiln, with two gas-escapes, *e* and *f*, on side opposite the grate. On each side of the kiln are discharging holes, *m* and *n*. From the fire-grate the products of combustion pass through a number of smaller holes, *g* and *h*, over the mass of wood and out at *i* and *j*.

Careful calculations made by Mr. Ljungberg gave the following results:—

One cubic metre of wood charged into the kiln contained—

Kilograms.	—	Carbon kilograms.	Hydrogen kilograms.
267·54	Cellulose	138·05	17·39
186·49	Moisture	—	20·72
1·67	Ash	—	—
—	Difference	—	1·48
455·70	Total....	138·05	39·59

And yielded:—

Kilograms.	—	Carbon kilograms.	Hydrogen kilograms.
111·00	Charcoal	91·30	4·60
3·40	Tar	2·76	0·37
6·74	Acetic acid ..	2·69	0·45
2·58	Methyl alcohol	0·96	0·32
1,695·93	Volatile gases	40·34	—
304·69	Water	—	33·85
—	Total....	138·05	39·59

Wood of the same character when carbonised in heaps, gave a yield, in volume, of 59·22 per cent.; a cubic metre contained 138·05 kilograms of charcoal, and yielded:—

	Carbon kilograms.
Anhydrous charcoal (90·61 kg.) ..	74·53
Loss of charcoal	63·52
Total.....	138·05

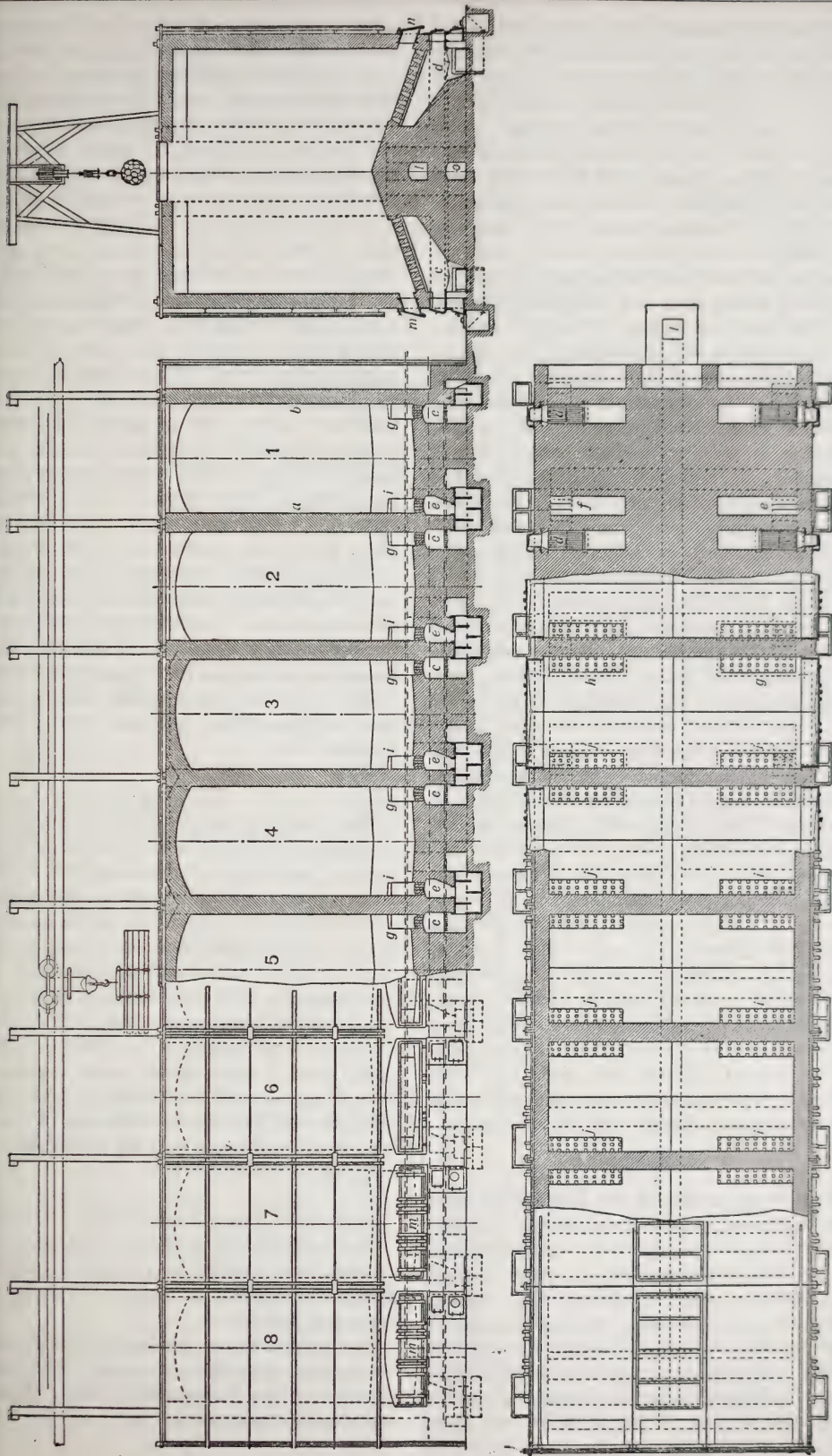
A yield of 72·56 per cent. by volume in the kilns, and of 59·22 per cent., in heaps, represents an increased yield in favour of the former of 22·53 per cent. In addition to the higher yield there is the further advantage of saving the by-products.

It is difficult to exaggerate the importance of an invention of this kind for the forestry and iron trade of Sweden. An increased yield of charcoal of 22 per cent. for the whole of the country represents a considerable national saving. This is, however, not all, for, with increased experience, there is no doubt that the yield will be much greater. There is also the value of the by-products to be taken into consideration.

Sandvik.

The pavilion of the Sandvik ironworks was of striking design, having a façade forming a model of a 15-ton steam-hammer. Within was a representative collection of the various products for which these works are justly celebrated. The works were founded in 1862 by Mr. G. F. Göransson after he had overcome the initial difficulties encountered by Sir Henry Bessemer in his early experiments. Besides tool steel, sledges and hammers, of which very fine examples were exhibited, railway tires were the chief objects manufactured in the early years of the works' existence. Among the objects exhibited was a railway waggon axle which had served for 21 years

FIG. 3.



LJUNGBERG'S CHARCOAL KILN.

and run 458,861 miles. In 1880 a rolling mill was erected for the manufacture of strips for lap-welded tubes, and as a proof of the skill attained in this work, there was exhibited a strip 21 inches wide of No. 6 gauge. This difficult size was rolled with perfectly true square edges. Since 1878 the works have made large quantities of wire rods, and at the present time Sandvik produces more flat wire for umbrella ribs than any other works in Europe. In 1884 a cold rolling mill was started for rolled bands, and as a sample of the work done the walls and ceiling of the pavilion were decorated with a single band 2,354 feet long, 8 inches wide, and of No. 26 gauge, weighing 1,146 lbs. As a contrast there was also exhibited a light band weighing only 43 lbs., although it was 4,317 feet long. It was $2\frac{3}{8}$ inches wide, and of No. 49 gauge (about $\frac{1}{4}$ thousandth part of an inch thick). There was also shown the largest band-saw in the world, 220 feet long, 12 inches wide, of No. 14 gauge, weighing 677 lbs. In 1893 a large rolling mill shop was erected for the hot-rolling of bands, and here was made the large hot-rolled band exhibited, the heaviest and longest ever rolled of this width and gauge. It was 298 feet long, 8 inches wide, of No. 8 gauge, and weighed 1,241 lbs. It was rolled in one heat from a bloom $4\frac{3}{8}$ inches thick and 11 feet long. The company having for many years made large quantities of solid blooms for bicycle tubes, in 1890 started the manufacture of hollow blooms, and erected large mills to cope with the growing demands of the bicycle trade. The works now possess 3 blast-furnaces, Bessemer works, 13 steam-hammers, 10 rolling mills, wire drawing mill, and cold rolling mill, 28 boilers, 35 steam-engines of an aggregate horse-power of 4,100, and 7 turbines of 700 horse-power. Open-hearth works are in course of erection. The out-turn of the works is 20,000 tons of finished steel annually; 1,800 men are employed, and 25,000 tons of charcoal are annually consumed in the blast-furnaces.

Bofors.

The large exhibit of the Bofors-Gullspång Company was housed in a separate pavilion representing a modern armour-clad turret with long cannon projecting from it, and an original and striking trophy of objects made by the company. This included models of a ram for the Swedish armour-clad *Thule*, made at Bofors in 1893, and weighing 9.2 tons; of an axle for the Russian Emperor's yacht *Standard*, made in 1894, and weighing 9 tons; and of two 10-in.

cannons, made for the Swedish armour-clad *Thor*, with a total length of 35 ft., and a weight of 29 tons, together with propellers and anchors of Bofors open-hearth steel. The works are among the oldest in Sweden and date back 250 years. The company was formed in 1873. In 1895 the late Alfred Nobel added the Björneborg works, purchased by him in 1894. Within the pavilion was a well-arranged collection of war material made of Swedish steel, including a 5-in. quick-firing gun for the Swedish navy, weighing 2.8 tons; a 3-in. mountain gun, weighing 230 lbs.; a 2-in. quick-firing gun, weighing 260 lbs.; a 6-in. trial gun, weighing 4.23 tons, with a gun carriage of ingenious design, patented by Mr. Silversparre, the chief engineer of the Bofors Cannon Factory. Besides these, there was a large collection of cast-steel objects, particularly field gun-tubes, cast to pattern, which are intended to be finished in the annealed state, and a large cog-ring with double helical cogs, over 11 ft. in diameter and weighing 5 tons, a propeller, weighing 6 tons, and some heavy anchors, and a nickel-steel armour plate 10 inches thick. The yearly production of the works comprises 6,000 tons of pig-iron, 10,000 tons of wrought-iron, 15,000 tons of acid open-hearth steel and iron castings, 10,000 tons of steel and iron bars, and 1,200 tons of manufactured iron.

Finspång.

The Finspång Company also had a pavilion of their own in the form of a pair of huge projectiles, surrounded by grass-grown mounds. In this were tastefully grouped a fine series of cannon, armour-piercing projectiles, armour plates, specimens of pig iron, castings, open-hearth steel ingots, rolled iron, steel plates, ore and limestone. The most noticeable exhibit was a 5-in. quick-firing cannon weighing 6.7 tons. The annual production of the works consists of 6,000 tons of open-hearth steel ingots, 600 tons of open-hearth steel castings, 600 tons of wrought-iron blooms, 1,200 tons of nails, 30 tons of rail spikes, 30 tons of horseshoes, and 1,000 tons of sheet-iron.

Iron and Steel in the Industrial Hall.

The exhibits of Fagersta, Söderfors, and Hofors were grouped in the great Industrial Hall, and formed a most instructive and attractive series.

The exhibit of the products of the Fagersta works was specially noteworthy. A beautiful display of saw blades proved that Fagersta's world-wide reputation for such objects is well

erved. Rolled and hammered steel was also shown, as well as rifle tubes, the manufacture of which, though of recent date, has assumed large proportions. Tubing and pipes, steel wire rope, spiral springs, were well represented. Most instructive was the collection of open-hearth chrome steel formed by the general manager, Mr. I. A. Brinell, whose researches in 1885 on the changes in the texture of steel on heating and cooling made an epoch in the metallurgy of iron, and formed the starting point of the long series of valuable researches with which the names of Osmond, Roberts-Austen, Howe, Sauveur, Stead, Hadfield, and Arnold are identified. These specimens of ingots and forged products were broken so as to display the fine fracture of the metal, and were accompanied by skilfully planned diagrams illustrating the change in structure of different steels treated in different ways. Of equal interest were the graphic statistical diagrams showing the growth of the company, the outturn of wrought-iron and steel having increased from 850 tons in 1850 to 4,500 tons in 1896.

The Söderfors works showed a very complete exhibit of open-hearth steel, arranged in a masterly manner by Mr. Tom Bergendal, whose long experience as representative of the Ironkontor at the Chicago World's Fair no doubt proved valuable to him in his task. This exhibit was specially remarkable for the difficult kinds of articles shown, including two $2\frac{1}{2}$ -ton anchors for the armour-clads *Thor* and *Vjörd*. Besides these, there were shown some fine blocks of pure Dannemora and Vigelsbro ores with analyses showing their remarkable freedom from phosphorus, a complete collection of pig iron brands, of wrought iron, and of manufactured steel objects such as anvils, vices, mining tools, wheels, axles, and springs. The educational value of the exhibit was enhanced by the numerous explanatory labels giving full results of the analyses and physical tests of the objects shown.

The Hofors works had an exhibit of similar character, except that there was a good display of basic open-hearth steel, including specimens of cold drawn open-hearth basic steel containing 0.80, 0.90 and 1 per cent. of carbon. An instructive object lesson was afforded by a series of 9 test fractures of this metal containing proportions of carbon, increasing from 0.20 to 1 per cent.

The Avesta works had a striking exhibit of boiler-plate, and of other grades of heavy and thin plates of remarkable ductility and soft-

ness. The works produce annually 20,000 tons of steel ingots, of which 1,500 tons are rolled into plates. Another admirable exhibit was that of the well-known Uddeholm works, founded in 1746.

Time will not permit me to describe the hundred other ironworks represented, nor the finished products, such as the celebrated cutlery of Eskilstuna, the Sheffield of Sweden, the beautiful enamelled iron ware of Kockum, and the bicycles, small arms, and artistic castings of Husqvarna.

Many of the mining and metallurgical exhibits were contributed by persons or firms who, with no possibility of deriving any pecuniary gain from the Exhibition, incurred expense from a patriotic desire to add to the value of the National Exhibition.

And this sketch of the more important mineral and metallurgical exhibits will, it is hoped, show that in educational value, in completeness and in originality, they were fully worthy of the classic home of scientific metallurgy, the land of Bergman, of Scheele, and of Berzelius.

Iron Trade Statistics.

In order to complete the statistical details contained in this paper, an extract from the official returns of the Swedish production of iron and steel last year is appended.

There were 124 works at which an aggregate of 140 blast-furnaces were in operation, and the production of pig iron comprised :—

	Tons.
Forge pig iron.....	246,022
Bessemer and open-hearth pig.....	225,103
Spiegeleisen.....	738
Foundry pig.....	15,284
Direct castings.....	7,271
Total.....	494,418

The blast-furnaces produced on an average 3,532 tons per furnace during the year. The time of production for each furnace was 271 days, and the mean daily outturn per furnace was 3.03 tons. Charcoal is practically the only fuel used in the Swedish blast-furnaces, for it is only in very rare cases, as in the manufacture of spiegeleisen, that a little English coke is used.

There were 137 wrought iron and steel works with 353 finery hearths, 4 puddling furnaces, 29 Bessemer converters, 41 open-hearth furnaces, and 4 crucible steel furnaces. The production comprised :—

	Tons.
Wrought iron	188,396
Bessemer ingots	114,120
Open-hearth ingots	142,301
Crucible steel ingots	604

Since 1870 the world's production of pig iron has increased from 12,000,000 to 30,000,000 tons, but during that time, whilst the United States, Germany, Russia and Austria-Hungary have gained ground, Sweden, like Great Britain, France and Belgium, has lost ground. The total production of pig iron from 1870 to 1896 inclusive was as follows:—

Country.	Millions of Tons.	Per cent.
Great Britain	198·3	37·0
United States	134·0	25·0
Germany and Luxemburg ...	91·8	17·2
France	45·3	8·5
Austria-Hungary	18·5	3·5
Belgium	18·2	3·4
Russia	17·8	3·3
Sweden	11·0	2·1
Total	534·9	100·0

The production of each country at the beginning and end of the period under consideration was as follows:—

Country.	1870. Millions of Tons.	1896. Millions of Tons.
Great Britain	6·0	8·6
United States	1·7	8·6
Germany and Luxemburg ...	1·4	6·4
France	1·2	2·3
Russia	0·4	1·5
Austria-Hungary	0·3	1·0
Belgium	0·6	0·9
Sweden	0·3	0·5
Total	11·9	29·8

The pig iron production in Great Britain and in the United States last year was practically the same, the official figures being 8,659,681 tons for the former and 8,623,127 tons for the latter.

The share taken by each country was as follows:—

Country.	1870. Per cent.	1896. Per cent.
Great Britain	50·5	29·0
United States	14·3	29·0
Germany and Luxemburg ..	11·8	21·5
France	10·1	7·7
Russia	3·3	5·0
Austria-Hungary	2·5	3·2
Belgium	5·0	3·0
Sweden	2·5	1·6
Total	100·0	100·0

The paper was illustrated by a number of lantern slides of the Exhibition and of the principal mines and works.

DISCUSSION.

Mr. J. E. STEAD said those present who were unable to go to Sweden and see the beautiful exhibits there, had enjoyed the next best thing in listening to the very excellent description which had been given to them and seeing the photographs which illustrated the paper. The four or five miles of ore deposits at Gellivare were very agreeable to hear of, and all the more so if a voyage were made from there to the Norwegian coast, as it would give Middlesborough the chance of living a few years longer, but he should much like to know what proportion of these ores was suitable for making Bessemer iron. Also, if the directors of the Gellivare Company had any idea of making the fine ore, after grinding it up and separating the phosphorus, into briquettes. If so, it would be important to know whether the phosphorus was sufficiently separated from the fine granular material to render it suitable for making Bessemer iron. Some 25 years ago he had some experience in working an identical material directly in a blast furnace, the ore being first crushed into fine powder, but the result was disastrous. The trial was made unfortunately by putting in about 20 per cent. of this fine material into the furnace together with other richer ores of a lumpier character and the result was that the ore got down to the bottom, and the whole mass closed up solidly, and it took about a week before they could get any iron out of the furnace, or get the blast through it. It was not sufficiently encouraging therefore to continue the experiment in any other proportions, though the wonderful account of the Edison works in America would lead to the belief that the material could be easily made into briquettes, and supplied in that form to Middlesborough. Another interesting point was the use of the dipping-needle to discover magnetic ore. He had also done this sufficiently to be able to verify what had been

stated, as he found that in Norway it was a very valuable instrument. The ores were polar, so that if you presented one part to a compass needle, it would attract the north pole, but on turning it round it would repel it. This property, when the ore was in seams, enabled one to discover the thickness of the seam. In this way, in the neighbourhood of Näverhaugen, directly opposite Gellivare, the deposits were tracked many miles by the dipping-needle alone, and the approximate thickness of the seam estimated with a fair degree of accuracy. On one side, facing in a southerly direction, it attracted the north pole, and on the other side it attracted the south pole, and exactly midway, the needle was parallel. The information given as to the utilisation of the refuse after the ore was separated, was quite new to him, and was very interesting. As he understood, by calcining the fine apatite with sulphate of soda, it formed a tetra-phosphate. This was very important, as it would stimulate the working of the more phosphoretic ores. It was also interesting to hear how largely water-power was used in Sweden. At a little mine in the neighbourhood of Näverhaugen the whole of the machinery was worked by water-power, and in connection with that he might mention a curious incident showing the honesty of the Norwegian peasant farmer. When the water was about to be taken for the purpose of the works, his permission was asked, which he readily gave; but there was a law that when water-power was taken in that way, a certain sum had to be paid to the owner of the land and a certain amount to the State. At the end of the year, therefore, the peasant was asked to come and receive his money, but he had said he did not want any money as he had given permission for it to be used. When told he had to be paid for it, he thought he would like to see what was done with it, and was therefore shown over the works, and when he found it went back into the stream after turning the machinery, he protested that they did not take the water at all, and he ought not to be paid for it. He only consented to receive the money on being informed that the proprietor would be liable to imprisonment if it were not paid.

Mr. H. BAUERMAN said he could really add nothing to this very interesting paper, though he had the opportunity of seeing the Exhibition on his return from Finland, and could confirm in every way what had been said as to the high character of the display. There was not a single thing shown which was not well worth inspection, and there was nothing of the advertising element to be seen. This was the first opportunity he had had of seeing what was being done in Sweden in connection with the newer developments of the iron trade. The manufacture of iron there dated a very long way back, and without giving up the methods by which their high reputation was attained, they had shown a remarkable talent in adapting themselves to the new order of things, taking up new methods, and attaining a very

high degree of excellence therein. There was a great development of the works at Domnarfvet, probably the largest charcoal ironworks in the world, certainly the largest driven by water-power, and the plant was of a very fine character. So again was the Finspong works, which was the famous ordnance factory of Sweden, and for nearly 300 years had almost a monopoly of a certain variety of cast-iron ordnance. That had now gone out, but Finspong had not abandoned it, for it was still made for certain purposes, hard rolls, and so on. In addition to that it had gone in for a remarkable development of everything connected with steel ordnance and armour plates, and it was very remarkable to see the way the old works brought themselves up to modern requirements. The Iron and Steel Institute would meet in Sweden next year, and he was sure the members would be glad to find in this paper a foretaste of what they would see there.

Mr. H. G. TURNER said he had no doubt the members of the Iron and Steel Institute who were about to visit Sweden would profit greatly by what had been brought forward in this excellent paper.

Mr. F. W. HARBORD said he was not able to go to Stockholm this year, and congratulated himself on having done the next best thing by being present to-night. What Mr. Stead had said about apatite was very important, quite apart from the supply of iron ores, there being a constant demand for phosphates.

Mr. D. A. LOUIS said he had the privilege last year of visiting one of the most magnificent displays connected with the iron manufacture he had ever seen, the Exhibition at Buda Pest; but from what Mr. Brough had said, the Exhibition at Stockholm must have far exceeded it in variety and importance. He was not sure that he had heard all that was said about apatite, but attempts had been made over and over again to convert apatite into soluble phosphate for agricultural purposes, grinding it and mixing it with soluble sulphates, and making it look very much like superphosphate, and sometimes adding a little of some other material, but he believed it had never proved very successful when applied to the soil. The polarity of iron-ore deposits was shown very strongly in Russia, and also in Norway. He had been much struck by the account of the charcoal kiln, which was a great improvement on anything which had been seen before.

Mr. A. BARCLAY asked what elevation the proposed railway would have to reach in going from Gellivare to the Norwegian coast.

The CHAIRMAN, in moving a vote of thanks to Mr. Brough, said there was one point which he should like to call attention to. Mr. Brough had

told them the relative per-centages of pig-iron produced by different countries, and pointed out that Sweden had fallen from $2\frac{1}{2}$ to 1·6 per cent. of the total; but it must not be forgotten that there was an increase in the quantity produced. It was because the total production of the world had increased, not because the actual production in Sweden had diminished, that the decrease in the per-centage had taken place. And it certainly was remarkable that, in spite of the very much cheaper processes now carried on in other countries, the demand for Swedish iron not only had not decreased, but had increased. For crucible steel, and for certain other purposes they still had to rely on Swedish iron; and he feared that would continue until some chemist could show them how to produce a mineral fuel as free from deleterious constituents, especially sulphur, as charcoal. So long as there was sulphur in coke, and none, or only a trace, in charcoal, Swedish iron would remain pre-eminent for those purposes in which extremely excellent quality was required. He was almost afraid when Mr. Brough spoke of the coinage of copper that he was going to advocate tri-metallism, and was glad to find that the volume of those coins was so enormous that they were not likely to be introduced into circulation. He had no doubt that the visit of the Iron and Steel Institute to Sweden would be most interesting, and his only fear was that after such a glowing description of the beautiful scenery of Stockholm and the neighbourhood, so many visitors might be attracted as would interfere with the business portion of the meeting.

The vote of thanks having been passed unanimously,

Mr. BROUGH, in reply, said he had been obliged to curtail the paper somewhat in reading, and some of the questions which had been put would be found to be already answered in it. With regard to the extent of the Gellivare deposits, it had been calculated by the Swedish geologists that the horizontal area of the deposit containing 61 per cent. of ore, was about 240,000 square yards, and there was consequently no immediate fear of the supply being exhausted. With regard to the use of fine ore for the manufacture of briquettes, he was unable to give any further information. The works for dressing the Gellivare ores had only just been started, and consequently no detailed results were yet published; but he had no doubt the directors would turn their attention to the line of operations marked out by Edison in the process to which Mr. Stead had referred. He could not say off-hand what elevation the proposed railway would reach, or what were the gradients, but it was an old proposal which was thrashed out by English engineers some years ago, and as far as he remembered, no engineering difficulties were anticipated. The great difficulty which proved fatal to the English company, and which was now occupying the attention of the Swedish Parliament, was the question of protecting the railway. The Swedish and

Norwegians rather looked upon it in the same light as many people regarded the Channel Tunnel, and it was supposed to be necessary to station a large garrison at the frontier to protect it in case of war. Now that the project was in Swedish hands it might be possible that things would go more smoothly, and certainly Swedish engineers regarded its construction as only a question of time. It would not be so much Gellivare as Kiirunavaara and Luossavaara which would be affected by it, as they were much nearer the coast of Norway than Gellivare was to Luleå, the port from which the ore was now shipped. It had been a source of great gratification to him to be allowed to submit this paper. He had on previous occasions described the metallurgical portion of the Exhibitions at Buda-Pest in 1885, at Barcelona in 1888, and at Kimberley in 1893. He was glad to be able to extend the series by giving a brief account of an Exhibition in which the mining and metallurgical exhibits presented far greater points of interest than in any Exhibition he had ever seen.

Miscellaneous.

SPANISH SILKWORM GUT.

An article of perhaps no little interest to many persons in this country, and of some substantial importance to Spanish industries, is the so-called gut from silkworms. This is useful for fishing purposes, partly on account of its great tenacity and partly owing to its transparent quality, the line attaching the hook when in the water not being visible. The United States Consular Agent at Grao says that since the decline of silk culture in Spain, the industry of making these silk threads has increased, leaving the peasants some profit. The prices, however, fluctuate according to the value of the silk. The higher the price of silk the fewer silkworms are used for fishing lines, and *vice versa*; yet about 4 per cent. of the silk grubs are destined yearly for the above named purpose. The manner of obtaining this threadlike gut is as follows:—After the grub has eaten enough mulberry leaves and before it begins to spin, which is during the months of May and June, it is thrown into vinegar for several hours. The insect is killed and the substance which the grub, if alive, would have spun into a cocoon, is forcibly drawn out from the dead worm into a much thicker and shorter silken thread, in which operation dexterity and experience on the part of the labourer are important. Two thick threads (from each grub) are placed for about four hours in clear cold water, after which they are dipped for ten or fifteen minutes in a solution of some caustic, for which purpose soft soap dissolved in water is used. This serves to loosen a fine outer skin, which is next

removed by the hands while the workman holds the thread between his teeth. The silk is then hung up so dry, care being taken to choose a shady place, as the sun has the effect of making them too brittle afterwards. In some parts of the country these silk rears are bleached with sulphur vapour, which makes them look beautifully glossy and snow-white, like spun glass, while those naturally dried retain always a yellowish tint. The quality of the gut is decided according to the healthy condition of the worm, "round" indicating a good quality, and "flat" an inferior one; also the length is important. The thickness depends upon the condition of the grub. Italy and Greece produce very fine and thin gut strings, and these are, to some extent, imported into Spain and sold again by weight at from £5 to £6 per pound avoirdupois. About 20,000 to 25,000 threads go to make up one pound. The Spanish production is made up neatly in bundles of one hundred threads and sold by ten such bundles, or one thousand threads, at about 16s. for the round kind and 6s. to 8s. for the flat kind. The time for selling this article wholesale is during January, February, March, and April; the retail trade is during the summer months and fishing season. Although Murcia is the principal place for this industry, yet most sales are made outside that city. The peasants of Murcia had a practice of raising their prices upon the slightest demand, which drove buyers from the place. The peasants now go every year, with their goods packed in boxes, up and down the entire coast of Spain on the Mediterranean as far as France. Valencia is considered the best market.

General Notes.

DIJON EXHIBITION, 1898.—Information has been received from the Foreign Office, through the Science and Art Department, that a Universal and International Exhibition will be opened at Dijon on the 1st June, 1898. The Exhibition will remain open until the 31st October. There will be 14 Sections—(1) Fine Arts, (2) Social Economy, (3) Hygiene, (4) Salvage, (5) Industrial and Decorative Arts, (6) Liberal Arts, Science, (6) Heating and Ventilation, (7) Electricity, Traction, (8) Military Art, (9) Manufactures, (10) Sport, (11) Exercises, Popular Games, (12) Conferences on Agriculture and Horticulture, (13) Education and Work of Women, (14) Commerce, Colonies. All communications should be addressed to the General Manager or to the Organising Committee, Rue Monge 38, Dijon.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

DECEMBER 15.—"The Purification of Sewage by

Bacteria." By SAMUEL RIDEAL, D.Sc. SIR DOUGLAS GALTON, K.C.B., F.R.S., will preside.

Papers for meetings after Christmas :—

"The Protection of Industrial Property." By J. F. ISELIN.

"The Projection of Luminous Objects in Space." By ERIC BRUCE, M.A.

"Aeronautics." By CAPTAIN B. BADEN-POWELL.

"Stage Mechanism." By EDWIN O. SACHS.

"The Recent History of Papermaking." By CLAYTON BEADLE.

"The Preparation of Meat Extracts." By C. R. VALENTINE.

"Children's Sight." By R. BRUDENELL CARTER, F.R.C.S.

"Fireproof Construction of Domestic Buildings." By THOMAS POTTER.

"Compensation to Workmen." By A. D. PROVAND, M.P.

"The Production of Low Temperatures." By DR CARL LINDE.

"The Cinematograph." By JULES FUERST.

"The Present Condition of the Sugar Industry." By T. R. TUFNELL.

"English Art in Illuminated MSS." By Sir E. MAUNDE THOMPSON, K.C.B.

"Renaissance Woodwork in England." By J. HUNGERFORD POLLEN.

"Recreations of an Indian Official." By The Right Honourable Sir MOUNTSTUART ELPHINSTONE GRANT-DUFF, G.C.S.I., C.I.E., F.R.S.

"The Plague in Bombay." By HERBERT MILLS BIRDWOOD, C.S.I.

"India and Sir Henry Maine." By CHARLES LEWIS TUPPER, C.S.I.

"Glass Painting." By LEWIS F. DAY.

INDIAN SECTION.

The meetings of this Section will take place on the following Thursdays, at 4.30 or 8 o'clock :—

January 20, February 17, March 10, 31, April 28, May 19.

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesday afternoons at 4.30 o'clock :—

January 18, February 15, March 15, April 5.

APPLIED ART SECTION.

The meetings of this Section will take place on the following Tuesday evenings, at 8 o'clock :—

January 25, February 22, March 8, 29, April 26, May 17.

CANTOR LECTURES.

The following courses of Cantor lectures will be delivered on Monday evenings, at Eight o'clock:—

Dr. EUGENE F. A. OBACH, F.I.C., F.C.S., M.I.E.E., "Gutta Percha." Three Lectures.

LECTURE III.—DECEMBER 13.

The Clean Material.—Chemical composition, mechanical and electrical properties—Application for various technical purposes—Use of hardened gutta percha for golf balls—Absorption of oxygen and behaviour towards ozone—Deterioration and preservation—Artificial substitutes for gutta percha—Concluding remarks.

CYRIL DAVENPORT, "Decorative Book-binding." Three Lectures.

January 24, 31, February 7.

HUGH STANNUS, "The Principles of Design in Form." Four Lectures.

February 14, 21, 28, March 7.

PROF. W. NOEL HARTLEY, F.R.S., "The Thermo-Chemistry of the Bessemer Process." Three Lectures.

March 14, 21, 28.

DR. D. MORRIS, C.M.G., "India Rubber." Two Lectures.

April 18, 25.

PROF. CARUS WILSON, "Electric Traction." Four Lectures.

May 2, 9, 16, 23.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, DEC. 13... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. Eugene F. A. Obach, "Gutta Percha." (Lecture III.—"The Clean Material.")

Scottish Society of Arts, 117, George-street, Edinburgh, 8 p.m. Prof. R. Hedyer Wallace, "The Adulteration of Dairy Produce."

Imperial Institute, South Kensington, 8½ p.m. Prof. Roberts-Austen, "Canada's Metals."

British Architects, 9, Conduit-street, W., 8 p.m. Reports on the Third Series of Experiments on Brickwork.

Camera Club, Charing-cross-road, W.C., 8½ p.m. Mr. W. Webster, "X Rays up to date."

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. Charles Harding, "The Weather Office and its Work."

TUESDAY, DEC. 14...Photographic (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m. Prof. Lippmann, "Colour Photography."

Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. R. B. Stanton, "The Great Landslides in the Canadian Pacific Railway in British Columbia."

Statistical, in the Theatre of the United Service Institution, Whitehall, S.W., 5½ p.m. Presidential Address by the Right Hon. L. H. Courtney, "Jevons's Coal Question—Thirty Years After."

Zoological, 3, Hanover-square, W., 8½ p.m. 1. Dr. E. A. Goeldi, "The *Lepidosiren paradoxa* from the Amazon." 2. Dr. A. G. Butler, "A Small Collection of Lepidoptera made by Mr. F. Gillett in Somaliland." 3. Mr. Oldfield Thomas, "The Mammals obtained by Mr. A. Whyte in N. Nyasaland, and presented to the British Museum by Sir H. H. Johnston, K.C.B.; being a Fifth Contribution to the Mammalogy of Nyasaland." 4. Rev. C. Pickard Cambridge, "A new Genus and Species of *Acaridea*."

Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m.

Colonial Inst., Northumberland-avenue, W.C., 4½ p.m. Mr. E. P. Gueritz, "British Borneo."

Asiatic, 22, Albemarle-street, W., 4 p.m. 1. Proposal to found Oriental School in London. 2. Dr. Hirshfield, "Some Legends of the Early Life of Muhammed."

WEDNESDAY, DEC. 15...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Dr. Samuel Rideal, "The Purification of Sewage by Bacteria."

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. R. C. Mossman, "Daily Values of Non-Instrumental Meteorological Phenomena in London, 1763-1896." 2. Mr. William Marriott, "The Rainfall of Seathwaite, Cumberland."

Geological, Burlington-house, W., 8 p.m.

Microscopical, 20, Hanover-square, W., 8 p.m. Mr. E. B. Stringer, "A New Form of Photo-micrographic Camera and Condensing System."

Chemical, Burlington-house, W., 8½ p.m. (Extra Meeting.) Prof. F. R. Japp's Kekulé Lecture.

Mining and Metallurgy, Geological Museum, Jermyn-street, S.W., 8 p.m. 1. Mr. W. Fischer Wilkinson, "Mining on the Black Reef, Witwatersrand Gold fields, South Africa." 2. Mr. Henry Watson, "Notes on Smelting at Broken Hill." 3. Mr. Gerald V. Hopkins, "Notes on the Buying and Sampling of Ores and the Working of Mines on the Tribut System in Chili."

THURSDAY, DEC. 16...Royal, Burlington-house, W., 4½ p.m. Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. H. M. Bernard, "The Affinities of the Madreporaria Genus *Alveopora*." 2. Messrs. H. and J. Groves, "West-Indian *Characeæ* collected by Mr. T. H. Blow."

Chemical, Burlington-house, W., 8 p.m. 1. Dr. J. Sudborough and Mr. Lorenzo Lloyd, "Stereo-Chemistry of Unsaturated Compounds. Part I.—Esterification of Substituted Acrylic Acids."

Dr. J. J. Sudborough and Mr. M. E. Feilman, "Formation and Hydrolysis of Esters." 3. Dr. M. Wilderman, "A New Method of Determining Freezing Points in very Dilute Solution."

London Institution, Finsbury-circus, E.C., 6 p.m. Mr. F. G. Edwards, "Mendelssohn."

Historical, 28, Jermyn-street, S.W., 8½ p.m. Electrical Engineers (Chemical Society Rooms), Burlington-house, W., 8 p.m. Continuation of Discussion on Mr. L. Epstein's Paper, "Accumulator Traction on Rails and Ordinary Roads."

Camera Club, Charing-cross-road, W.C., 8½ p.m. Dr. Lindsay Johnson, "Rome and Roman Life the First Century."

FRIDAY, DEC. 17...Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Mr. Archer D. Keigwin, "The Elastic Properties of Steel Wire." 2. Mr. W. Brown, "The Elasticity of Portland Cement." Society for the Encouragement of Indian Art (East Conference-hall, Imperial Institute, South Kensington), 4½ p.m. General Annual Meeting. Quekett Microscopical Club, 20, Hanover-square, W., 8 p.m.

Journal of the Society of Arts.

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FRIDAY, DECEMBER 17, 1897.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****JUVENILE LECTURES.**

The usual short course of lectures adapted for a juvenile audience will be given on Wednesday evenings, January 5 and 12, 1898, by Professor WILLIAM RAMSAY, Ph.D., F.R.S., on "Fire."

The lectures will commence at 7 o'clock. Special tickets are required for these lectures, which can be obtained on application to the Secretary. A sufficient number of tickets to fill the room will be issued to members in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each member is entitled to a ticket admitting two children and an adult. Early application should be made.

CANTOR LECTURES.

On Monday evening, 13th inst., Dr. EUGENE OBACH, F.C.S., delivered the third and last lecture of his course on "Gutta Percha."

The CHAIRMAN (Mr. Alexander Siemens) proposed a vote of thanks to the lecturer for his course of lectures, which was carried unanimously.

The first lecture will be published in the next number of the *Journal*.

LIST OF MEMBERS.

The new edition of the List of Members of the Society is now ready, and can be obtained by Members on application to the Secretary.

Proceedings of the Society.**FIFTH ORDINARY MEETING.**

Wednesday, December 15, 1897; Sir DOUGLAS GALTON, K.C.B., F.R.S., Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Bailey, Hubert Thomas, 4, St. Dunstan's-alley, E.C. Berge, Sir John Henry Gibbs, K.C.M.G., Foreign-office, S.W.

Bond, Walter George Alick, Holmby, Fortune-green-road, West Hampstead, N.W.

Clarke, Charles Bridger Orme, 4, St. Dunstan's-alley, E.C.

Pitcher, Colonel D. G., Residency Post-office, Gwalior, Central India.

Whinfield, John Henry Richard, 8, Great George-street, S.W., and Brambletye, Cavendish-road, Sutton, Surrey.

Wolfe, Miss Emma Sarah, High Broom, Crowborough, Sussex.

The following candidates were balloted for and duly elected Members of the Society:—

Mehta, R. D., C.I.E., 55, Canning-street, Calcutta
Milnes, William Henry, 56, Croftdown-road, N.W.

Morton, George Arthur, 22, Ridley-villas, Newcastle-on-Tyne

Penton, Edward, 1, Mortimer-street, W.

Stansfield, Alfred, B.Sc., Aldersyde, Hainault-road, Leytonstone, N.E.

Stearn, Charles Henry, Avoca-lodge, Branstone-road, Kew-gardens

Steel, Fred W., Tamunua, Navua-river, Fiji

Whitlock, Alfred Allen, Park-street, Dover

Woods, Henry, A.R.A., Venice

The paper read was—

THE PURIFICATION OF SEWAGE BY BACTERIA.

BY SAMUEL RIDEAL, D.SC. LOND., F.I.C.

The success which has attended the experiments at Exeter on the disposal of sewage by means of what is known as the septic tank process, makes the present time a fitting one for reviewing the present position in regard to the problem of sewage disposal.

The various methods based upon chemical precipitation and subsequent land treatment of the effluent have given results which have seldom been satisfactory from an economic point of view, and which have often been disastrous from other causes to such an extent that many authorities are now refraining from the erection of works on the old lines.

The difficulties which have arisen have usually proved on investigation to be due either to the injudicious and extravagant use of chemicals or to the unsuitability of the land acquired for the treatment of the effluent. The former of these are now sufficiently well known for them to be guarded against, but the nature of the land required for sewage disposal

is often outside the control of the local authority, and its value in the neighbourhood of populous centres makes it almost impossible in many cases to dispose economically of sewage in this way.

When one looks back to a period of 30 years ago, it will be recollected that at that time methods of upward filtration were suggested in the place of chemical precipitation, and the results obtained were of such a satisfactory character that it is difficult to understand how authorities almost universally adopted the chemical treatment. There can be no doubt that in slow upward filtration of sewage the arrested suspended matter slowly disappears just in the same way as when the solid matter of sewage, after being removed by straining or by chemical precipitation, subsequently disappears when dug into the ground or buried beneath the surface.

Similar changes take place in mud banks in estuaries, below the surface of water, and the conversion of organic matter of vegetable or animal origin at the bottom of a stagnant pool into harmless gases is of the same nature.

Such transformations are of such a subtle character that for the most part they have escaped attention, and yet, without doubt, they are as important as those more prominent ones which take place in the presence of light and air.

It would seem that in nearly all cases of destruction of organic matter this preliminary disintegration takes place before the final oxidation of the elements.

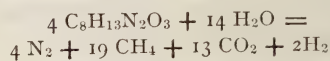
Even in direct combustion, the preliminary charring is of a similar character, and in some cases, as for example, the conversion of starch into dextrin, the change can be imitated by chemical means, or by the action of enzymes. Solid organic matter, capable of undergoing change even in the presence of air, can only oxidise directly on its surface, whereas in a rotten apple or cheese, changes take place beneath the surface, which pave the way for the final oxidation.

Organic matter in solution similarly seldom oxidises directly to its final oxidised products, but passes through intermediate conditions until the more complex organic forms are resolved into others of more simple structure, and these are subsequently burnt up to the stable oxidised compounds—water and carbonic acid.

It is difficult to give a single name to these phenomena, the older terms "decay," "putrefaction" and "cremation" did not sufficiently

differentiate between them and the combustion which follows so closely. The term "bacteriolysis" has been suggested, and it seems a useful one to retain, although in the changes which take place in digestion for example, which are of exactly the same type, enzymes and not bacteria are concerned. When the action is effected by chemical agents, the term "hydrolysis" has already been used by chemists for such breaking down of organic matter. Other cases, in which the decomposition takes place without any absorption of water, may be grouped under the general term "fermentation." In some of these oxidation is simulated, since the organic matter is partly converted into final stable oxidised compounds. The oxygen, however, in such products is not derived from the air, but is that which was originally present in the organic matter or water taking part in the reaction.

Thus to take a specific example: albumen contains the elements carbon, hydrogen, nitrogen, and oxygen in the ratio represented by the empirical formula $C_8H_{13}N_2O_3$. An anaerobic change, due to hydrolysis, could be expressed thus:—



Such an ideal change would result in the production of all the gases which are commonly met with in these decompositions and leave no soluble organic matter for oxidation. Non-nitrogenous substances like cellulose and woody fibre can similarly break down into starch, sugar, &c., and in presence of yeast into carbonic acid and alcohol. In most natural anaerobic changes of this character it is found however that there are residual compounds containing nitrogen, of a humus-like character which have been little examined. These compounds are very stable, and resist chemical action. In vegetable and peaty soils they seem to exist in appreciable quantity. Adeney has noticed their formation in his experiments and in the Exeter septic tank the black suspended matter is of similar character. That this stable nitrogenous matter does slowly disintegrate is shown from the experiments at Harpenden, where crops have grown on unmanured land for long periods, under such conditions that it is difficult to ascribe any other source for their nitrogen.

I have recently pointed out that when these changes are brought about by organisms which are usually anaerobes, like *B. prodigiosus* and *B. fluorescens liquefaciens*, the breakin

down of gelatine to albumoses, ammonia, peptones, &c., is not accompanied by any absorption of oxygen, or the formation of any oxidised products, and it is, moreover, obvious that in the natural process of digestion, solid foods, both nitrogenous and non-nitrogenous, are digested in the stomach and intestines before the products are absorbed by the blood and so rendered useful by oxidation. I have also noticed in laboratory experiments the production of inflammable gases from different kinds of cellulose, paper, cotton wool, &c., placed in water and inoculated with sewage organisms.

The amount of oxygen required to render occurring in sewage, of course depends on the species of the bacteria which are acting, as they determine whether the result should be a complete burning to CO₂, H₂O, and N, or a partial decomposition to equally harmless compounds like NH₃ and CH₄. Thus *Streptococcus longus* liquefies fibrin to ammonia, methylamine, and trimethylamine, and leaves in solution tyrosine, leucine, fatty acids, succinic acid, collidine, and peptones (Emmerlich, Ber. 1897, 30, 1863). Elastin, with anaerobic organisms, evolves carbonic acid, hydrogen, methane, and nitrogen, whilst the sulphur remains in solution as mercaptan, and

is not evolved as sulphuretted hydrogen (Zoja, Zeit, Physiol. Chem., 1897, 23, 236). Grass similarly evolves carbonic acid and nitrogen, under the action of *B. subtilis* and other organisms. *B. mycoides* also acts upon the carbohydrates in grass, and ferments glucose to inactive lactic acid, and hydrolyses cane-sugar, maltose, and glycogen (Emmerlich, Ber., 1897, 30, 1896).

The gases found in the septic tank at Exeter are as follows :—

	Per Cent.		By Volume.	
CO ₂	0·3	....	....	0·6
CH ₄	20·3	....	....	24·4
H	18·2	....	....	36·4
N	61·2	....	....	38·6
	100·0		100·0	

Much of the carbonic acid dissolves in the water, as does also the ammonia produced, whilst the hydrogen, from its easy diffusibility, escapes from the tank more rapidly than the heavier gases. No sulphuretted hydrogen has been found in the septic tank, the changes, therefore, are similar to those which take place in the anaerobic fermentation of elastin.

The following Table shows the weight of oxygen required to oxidise some typical organic compounds completely to their final stable products :—

Substance.	Empirical Formula.	Per-centage composition.				Oxygen required by one part to convert it into :—	
		C	H	N	O	CO ₂ , H ₂ O, and N.	CO ₂ , NH ₃ , and H ₂ O.
Albumin	C ₈ H ₁₃ N ₂ O ₃ ?	53·4	7·1	15·8	23·7	1·754	1·48
Gelatin	..	50	6·6	15·3	25·1	1·61	1·33
Starch, cellulose, and woody fibre.....	C ₆ H ₁₀ O ₅	44	6·2	..	49·4	1·184	1·184
Ammonium amidoacetate (ammonium salt of glycocine)	C ₂ H ₈ N ₂ O ₂	26·1	8·76	30·43	34·78	1·043	0·53
Urea	CH ₄ N ₂ O	20	6·7	46·7	2·66	0·803	0

The second important change necessary for the complete destruction of the organic matter, involves the essential that free or available oxygen, either from the air or oxidised compounds, shall be present. It has been customary in recent years in discussing the action which take place in filter beds and in rivers, as well as beneath the surface of sewage farms, to call the phenomena “nitrification,” but it is necessary to point out that the oxidation of the organic carbon also takes place at this stage. The more general term

“oxidation” is therefore more useful, and indicates more clearly what takes place in the final purification of a sewage effluent. The experiments carried out by the Massachusetts Board of Health, and by the London County Council at Barking, have been directed almost entirely to this second and final stage in the treatment of sewage. And in the latter experiments, with the acre filter bed, it will be recollected that only sewage which had been chemically treated or in which the solids and suspended matters had been removed was used.

It is also important in discussing this question to recollect that the anaerobic or hydrolytic change takes place very rapidly under favourable conditions, and that it is not unusual to find, especially in towns in which the sewers are old and tortuous, a crude sewage in which these preliminary disintegrating changes have taken place to a very considerable extent.

It is easy to see, by calculation, that an average sewage from a water-closet town, with a water supply of, say, 25 gallons per head, should produce a sewage which, when fresh, should contain about 10 parts of organic nitrogen per 100,000, but one finds in the majority of cases the sewage of a town contains only from 1 to 2 parts of organic nitrogen, and in many cases less than this amount. This difference must be due to the very rapid breaking up of the organic matter present by the anaerobic methods described, and is accompanied by a corresponding increase in the ammonia from nothing up to 8 parts per 100,000, less the loss which may be due to the evolution of free nitrogen gas and possibly oxides of nitrogen.

I have gone into this subject at some length as, until quite recently it was believed that the purification of sewage was simply a process of oxidation, and that air, or oxidising chemicals were the chief factors required.

These introductory remarks on the theory of the bacterial processes involved enable me to give a brief outline of the different methods which are now being tried for dealing with raw sewage, taking them in their order of introduction.

1892. Scott-Moncrieff introduced his cultivation filter bed. In this system the raw sewage passes, without any screening, into the bottom of an upward filter bed fitted with a false bottom. The liquid portion rises through this false bottom, and then through successive layers of flint, coke, and gravel of about 14 inches in thickness, and then reaches the level of the outflow pipe, about two inches below the level of the invert drain. The solids and suspended matter are thus arrested at the bottom of the filter bed and finally disappear or dissolve anaerobically in the open space below the filter. The flint and coke form surfaces upon which the further changes take place and become more and more aerobic in character towards the surface of the bed.

"By the concentration of the crude sewage in the filter bed the bacteria are provided with an unlimited supply of nutritive material, and so are capable of indefinite multiplication,

while at the same time their self-injurious products are being constantly swept away.

"In order to still further improve the quality of the effluent by longitudinal filtration, by oxidation, and by the action of micro-organisms, Mr. Scott-Moncrieff devised what he has termed nitrifying channels. These in their simplest form consist of half channel pipes joined together with cement and filled with coke. Mr. Moncrieff hoped that by allowing the effluent from the filter bed to flow down a sufficiently long channel, the organic nitrogen would be oxidised into nitrates and nitrites. His expectation was only realised in part, because the effluent still contained sufficient organic matter to call for further oxidation, and so to prevent the formation of, or even to de-oxidise, existing nitrites and nitrates."

Since 1892, Mr. Moncrieff has modified his original plans by arranging two or more filter beds, so as to allow of their periodic aëration and resting. For this purpose the contents of the tank are emptied by means of a penstock at its lower end. Among the organisms isolated from the effluent, the following have been identified:—*B. fluorescens liquefaciens*, *B. subtilis*, *Proteus vulgaris*, *B. figurans*, *B. luteus*, *B. mycoides*, and *Cladotrix dichotoma*.

1895. *The Exeter System*.—In this process Mr. Cameron effects the liquefaction of the solids in a closed tank sunk beneath the surface of the ground. The raw sewage flows into one or more grit chambers, and then over a partition into the tank, where it slowly passes to the further end, the effluent passing out of the tank through a slotted pipe placed beneath the surface of the liquid transversely to the flow. The tank effluent passes over an aërating weir and thence to coke breeze filter beds arranged in series, and fitted with automatic gear, so that a cycle of aëration, filling, resting full, and emptying is ensured to each filter in rotation.

In the present installation at Belle Isle, the sewage from about 2,000 inhabitants has been dealt with continuously for nearly eighteen months. The process has been carefully examined by several experts, and recently a Local Government Board inquiry has been held with a view to extending the system to the whole of the city. In the new installation provision has been made for a nominal daily flow of 1,064,610 gallons, or for a prospective population of about 46,000. The sewage flows by gravity to the disposal works, which consist of six tanks, each 35 by 181 by 7 ft., and

having a total capacity of 262,422 cubic feet. These tanks will be roofed by concrete arches, carried by brick piers and covered over with soil. The tanks are so arranged as to be used either singly or in series: and when the outfall sewer is running full bore the contents will be changed in $7\frac{1}{2}$ hours. The solid matter in suspension will dissolve in these tanks, with the exception of the small quantity of black humus, which, at long intervals, can be removed from the deposit chamber. The effluent passes over aerating weirs to filters which will deal with a quantity of sewage equal to twice the daily flow from the prospective population, and with storm water up to $1\frac{1}{2}$ times the volume of the sewage. Storm water in excess of this amount passes over a series of aerating weirs into the river or on to the land. By means of modules, placed between the tanks and filters, their work is made uniform throughout the day.

The filters are eight in number, and have a total area of $2\frac{1}{2}$ acres, or 13,613 feet each and four feet deep with a working capacity of 2,500,000 gallons a day, and will be filled and emptied by automatic gear. It will be seen that Mr. Cameron, like Mr. Scott-Moncrieff, carefully differentiates between the hydrolytic or solution process, and the subsequent oxidation required for final purification.

Dr. Sims Woodhead has shown that the liquefying anaerobic organisms are more numerous in the tank than in the effluent or filtrate, whilst the liquefying aerobic organisms, although still present, diminish in quantity but again increase when the tank effluent passes over the aerating weir. It would seem therefore that although primarily, the septic tank has an anaerobic function, the aerobes are capable of surviving and even doing a certain amount of oxidising work. Their product nitric acid appears in small quantities in tank effluents, but it is probable that, as pointed out later, the nitrates are reduced as soon as they are formed, evolving nitrogen, and causing a further destruction of the residual organic matter.

1896. *The Sutton Process*.—In the autumn of 1896 the Sutton District Council at the advice of Mr. Dibdin constructed an open tank filled with coarse burnt ballast, which failed to pass through a half-inch mesh. The crude sewage, partially screened, was turned on to this bacteria tank, "the idea being first to ensure the coarse suspended matters getting into the whole body of the filter instead of forming a layer on the top; and secondly to also insure

the body of the filter being thoroughly aerated when the water was drawn off, it being impossible for such a coarse bed to become water-logged." The filtrate from such coarse filters is finally purified by a fine coke breeze filter similar to those used in the Barking experiments with chemically treated effluents, and to those used by Mr. Cameron for purifying the septic tank effluents.

Although this tank is designed to work continuously, it is obvious that either it must be emptied very rapidly, or a system of duplication such as has been found necessary by Mr. Scott-Moncrieff must be resorted to. It is further to be noticed that the object is to arrest the solids in the body, and not on the surface of the bed, and therefore in the dark, and, to a certain extent, away from the air, although the periodic emptying is designed to introduce oxygen into the bed and is therefore *opposite* in design to the Cameron and Scott-Moncrieff systems. Since, as pointed out earlier in this paper, a breaking down without oxygen is an essential preliminary, we have in this bacteria tank an anaerobic change taking place in spite of the aerobic conditions, and even if aerobic bacteria or higher animals (larvae, &c., which abound in summer on the surface of such tanks) do bring on the dissolution of the organic matter, the change is still primarily one in which atmospheric oxygen is only indirectly advantageous.

1897. *The Ducat System*.—This has been described by Dr. Barwise as the beehive tank, and by the inventor as an aerated bacterial self-acting filter. It is designed to be continuous in its action, and by heating arrangements it is hoped will also be independent of the seasonable temperature variations. The walls of the tank are made of perforated tiles or drain-pipes, so that air can blow in to the body of the filter. The material is coarse at the top, and fine at the bottom; it is therefore similar in function to the Sutton system, except that the coarse filter is superposed on the finer one. It further resembles the Sutton design inasmuch as atmospheric oxygen is intentionally brought into intimate contact with the sewage at once without giving any period of anaerobic change as in the two earlier processes already described. I have pointed out elsewhere that the first changes in the dissolution of the organic matter in sewage may be very rapid, and in towns with old sewers, the sewage to be treated may be so far advanced in anaerobic decomposition that a filter of this description can at once deal with it.

In judging the results obtained by these newer processes of sewage purification we are brought face to face with the problem as to what may be regarded as a satisfactory effluent. It will be recollected that the Rivers Pollution Commission sought to legalise, amongst other standards, 2 parts of organic carbon and 0·3 of organic nitrogen per 100,000 for liquids which might safely be discharged into streams. Since the date of this Commission various water-boards and authorities in this country have made modifications in these standards or their equivalents in terms of "oxygen consumed" and "albuminoid ammonia," but, so far as I am aware, no authority officially permits a proportional variation in the quality of an effluent to its amount or the volume of the river into which it discharges; nor have we at present any authority which attaches a value to the ratio of the remaining organic matter to the available or potential purification which exist in the nitrites or nitrates in effluents.

It ought to be laid down as a principle that the quality of a satisfactory effluent must vary according to its destination, whether a large river, or land, or an estuary, or whether riparian towns below might be affected, more especially if they use the stream as a water supply. The velocity of current and aëration of a river, and the presence of vegetation will also greatly affect the result. My own work on the subject shows that effluents in an active bacterial state undergo vigorous nitrification even without the addition of more water: in a large river, well supplied with oxygen, the changes are still more rapid, and in a short time the purification is complete. Under favourable circumstances, therefore, the conditions need not be so rigorous as with a smaller stream, in places where a water supply has unfortunately to be drawn at a point lower down.

The standard of 0·3 parts of organic N per 100,000 was founded on the idea current at that date (1873) that the chief purification depended on chemical oxidation during the era when sand filtration only was tried, and it was formulated on the grounds then adduced that "no river in the United Kingdom was long enough to secure the oxidation and destruction of any sewage," whereas Sir E. Frankland, a member of this Commission, states in his book on water analysis, that "Nitrates and nitrites are rapidly destroyed when the organic matter in the water containing them enters into putrefaction, a condition which often occurs in streams or reservoirs containing

much organic matter. The organic matter in deep well water, too, is often oxidised at the expense of nitrates." The nitrates and nitrites, therefore, evidently supply a store of oxygen for the destruction of the organic matter through the agency of active bacteria. Thus, in the case of the River Exe, Dr. Dupré and myself found, in 1895, that the discharge into it of the sewage of 40,000 people, the river being 40 times the volume of the sewage, was not indicated by any serious alteration in the quality of the stream. Dupré has by direct experiment succeeded in arresting putrefaction of London sewage by adding 35 times its volume of London tap water. The Oxford public analyst, in a report to the local county council, dated November 13, 1897, corroborates this rapid change in flow, laying stress on the "natural agencies," now known to be almost entirely bacterial.

But the changes in the natural purification of sewage lead more to the production of *nitrites* than of *nitrates*. In published analyses the former have not been sufficiently recognised. But nitrous acid and nitrites are well-known carriers of oxygen; they readily absorb oxygen from the atmosphere, or dissolved oxygen from a river water, and yield it again to the organic impurities, oxidising them to carbonic acid and water. From this useful instability, they count in many analyses in the "oxygen consumed," and, therefore, lead to a higher estimate of the organic matter.

As an example of the production of nitrites, three Exeter filtrates, which on June 18th contained only "heavy traces," were analysed on June 30th, twelve days later.

PARTS PER 100,000.

Number.	Original N as nitrate.	After 12 days.	Original N as nitrite.	After 12 days.
VI.	1·01	1·152	very heavy trace	0·48
VII.	0·590	0·624	heavy trace	0·666
VIII.	0·696	0·768	heavy trace	0·55

A later sample will further illustrate this instability.

	Nitrogen as Nitrates.	Nitrogen as Nitrites.
Nov. 10th, 1897	1·49	·030
Nov. 18th, "	1·51	·74
Dec. 2nd, "	2·58	trace

In an effluent from the septic tank at Exeter, on November 10th, the nitrate was 0.030, the nitrite none; on December 2nd, the nitrate was 0.060, the nitrite excessive, so that the production of nitrite can proceed, in some cases, independently of the reduction of nitrate.

So long ago as 1886, Gayon and Dupetit (*Station Agronomique de Bordeaux*, 1886) investigated the change of nitrates to nitrites with evolution of nitrogen oxides and nitrogen gas by the agency of bacteria. The disengagement of these gases is an important and till now unrecognised element in the purification, as they are without odour and innocuous. Two organisms were isolated from sewage, which, in the presence of organic matter, decomposed nitrates with production of nitrogen and nitrous oxide. They state that in a nitrated medium they were anaerobic, *taking oxygen from the nitrate*, and that in certain solutions as much as 9 grammes per litre of nitrate could be decomposed. By exact analysis of the evolved

gases, and of the fermented liquids, the authors show that *the whole of the nitrogen of the nitrate is evolved as gas, and that the whole of the oxygen of the nitric acid is combined with the carbon of the organic matter to form CO₂*, a portion of which may be evolved as gas, while the remainder combines with the base to form an acid carbonate. *Organic matter is essential to the reaction.* "1 grm. KNO₃ requires 0.148 C or 0.273 grm. of albuminoid matter for its complete decomposition." The N + N₂O + CO₂ account for all the nitrogen, carbon, and available oxygen of the nitrate.

The denitrifying bacteria will not develop in liquids deprived of nitrate and out of contact with air, nor will they attack organic matter under these circumstances. The authors further proved denitrification to be a fermentation which consists in the *direct burning up of organic carbon at the expense of the oxygen of a nitrate*.

No.	Description.	N as nitrate.	o in nitrate N ₂ : O ₅	N as nitrite.	o in nitrite N ₂ : O ₃	Total available oxygen (lowest estimate).	Oxygen con- sumed in 4 hours.	Ratio of avail- able o to o consumed.	Volumes of oxygen-saturated water required to yield all the o consumed.	Volumes of oxygen-saturated water required to supplement the available oxygen.	Albuminoid NH ₃ .	Per-centage of N oxidised.
1	Exeter septic tank filtrates } average, Nov. 1896	.496	1.42	heavy	...	1.83	0.91	2 : 1	1.10	0	0.50	12
2	Ditto, June, 1897	.848	2.44	.565	.970	3.82	0.966	4 : 1	1.21	0	0.412	33
3	Weybridge raw sewage, June } 12th, 1896	0	0	0	0	0	4.00	0 : 1	5	5	1.05	0
4	Yeovil raw sewage, June 15th, } 1896	0	0	0	0	0	5.87	0 : 1	7	7	1.135	0
5	Wembley sewage farm efflu- } ent, June 22nd, 1896	.75	2.14	heavy	...	2.14	1.79	1.2 : 1	2.1	0	0.90	48.7
6	Aylesbury sewage effluent, } June 22nd, 1894	.08	0.23	trace	...	0.23	7.23	.032 : 1	8.4	8	1.3	1.3
7	Croydon sewage farm effluent, } April 26th, 1895	.88	2.51	heavy	...	2.51	1.29	1.94 : 1	1.5	0	0.07	63
8	Precipitation and coke breeze } filter, Dibdin, 1894	.202	.577	...	...	.577	1.04	.55 : 1	1.34	.55	...	...
9	Ditto, 1895	1.10	3.14	...	...	3.14	1.26	2.5 : 1	1.47	0	...	...
10	Pearmain & Moore's average : } Exeter filtrate effluent, May } and June, 1897	1.3	3.71	none ?	...	3.71	0.47	8 : 1	.55	0	0.16	43
11	Dibdin's average Exeter fil- } trates, April and June, 1897 }	.504	1.44	.361	.433	1.87	0.55	3.4 : 1	.636	0	0.11	17
12	Exeter raw sewage	0	0	0	0	0	6.56	0 : 1	8	8	1.40	0
13	Exeter septic tank effluent	.041	.117	trace	...	.117	4.32	.027 : 1	5	4.0	0.64	1.0
14	Sutton crude sewage	0	0	.021	.037	.037	6.5	.006 : 1	7.5	7.4	1.13	0.2
15	Sutton effluent	.587	1.68	.23	.28	2.17	2.39	.9 : 1	2.8	0.2	0.47	19
16	Sutton filtrate	1.53	4.37	0.067	.115	4.485	0.92	5 : 1	1.1	0	0.24	54
17	River Brent—Perivale Rec- } tory—June, 1896	0	0	faint trace	...	0	2.32	0 : 1	3	3	0.65	0

Therefore, after partial nitrification in a filter, this action of another class of bacteria, which absolutely require a certain amount of organic carbon as food, converts the latter into car-

bonic acid and harmless gases such as N and N₂O, the oxygen required being taken from the air or from that dissolved in the water. The change is illustrated in the above

table of typical sewages and effluents, in which the "available oxygen" is that present as nitrate or nitrite, and the amount of carbonaceous matter requiring destruction is measured by the ordinary figure of "oxygen consumed" as determined by permanganate, since after four hours heating with permanganate no dangerous matter can be left. The table also shows that the available oxygen as nitrates and nitrites is in certain effluents quite sufficient in most cases to deal with the organic matter, even without help of the oxygen dissolved in river water.

My friend, Mr. Henry Law, has suggested that the conditions for the discharge of any effluent into a stream may be expressed in the following form:—

X = flow of stream in 100 litres per minute.

O = grammes of free oxygen in 100 litres of the stream.

S = number of 100 litres of effluent discharged per minute.

n = grammes of available oxygen as nitrates and nitrites in 100 litres of effluent.

m = grammes of "oxygen required to consume" the organic matter in 100 litres of the effluent as determined by the permanganate test.

C = number of times that the free oxygen in the stream exceeds that required to oxidize the organic matter in the effluent.

Then—

Quantity of free oxygen in stream = X O

Oxygen required by the effluent = (m-n) S.

So that $X O = C (m-n) S$.

When there are no nitrates in the fluid, then—

$$X O = C m S.$$

When $X O > (m-n) S$, we have stability, and when $X O < (m-n) S$, the effluent should be condemned.

I have already commented favourably in a former paper ("J. San. Inst." xviii. 76) on the suggestion of Adeney ("Royal Dublin Soc.'s Trans." Sept. 1895) that "The limit of impurity allowed to a given water (or effluent) should be such that, when a given volume of it is mixed with a given body of fully aerated water, and the mixture kept in a bottle out of contact with air for a sufficient length of time, a decided oxidation of the ammonia originally present into nitrous or nitric acid shall be indicated." Such an occurrence would prove a healthy state

of change, and would be accompanied by a disappearance of colour and a reduction of the total organic matter.

A large number of the published analyses of effluents are vitiated by the fact that the samples have not been analysed until some days after collection, frequently at the end of a long transit by rail or other conveyance, during which the agitation and inevitable contact with air will have considerably altered the composition in a favourable sense. It is, therefore, desirable, wherever possible, to analyse an effluent within a very brief time from its collection, and the more important determinations should be made on the spot within a few minutes of the discharge. Although this is undoubtedly the only fair procedure, such analyses are not of course comparable with those carried out under the usual conditions which give an apparently higher quality to the effluent, but they demonstrate the existence of the rapid and beneficial improvement in some effluents which I consider, with Adeney, one of the main criteria of safety.

In the examination of sewages and effluents there is a great difficulty in obtaining reliable samples, chiefly on account of the variation of rainfall and evaporation. In chemical precipitation there is also a dilution by the reagents used. The strength of sewage itself is continually varying during the 24 hours, and it takes a considerable time for a given sewage to appear at the effluent outlet. Consequently, the collection of isolated samples, especially when, as in recent cases, the sewage and effluent are taken almost at the same time, furnishes no index whatever to the extent of purification. Urine and fæces contain a large but fairly constant proportion of chlorine, whereas river water contains much less, and rainwater very little; so that an approximate calculation may be made of the degree of excretory pollution from the amount of chlorine. The only satisfactory basis for a comparison between effluents, or between them and sewages, is to calculate them to a uniform standard of chlorine. Even in cases like that of the Salford sewage, where the chlorine figure in the sewage was raised by factory discharges to upwards of 60 parts per 100,000, the calculation would still establish an individual correspondence between sewage and effluent, while what may be termed the extraneous chloride could be allowed for.

The processes at work in destroying the putrescible matter in sewage involve its tran-

sition into products yielding albuminoid and free ammonia ; an increase in the free ammonia, therefore, is actually a proof that so much destruction of nitrogenous organic matter has occurred. Albuminoid ammonia in an effluent may also be a good sign, indicating either that organic matter as sediment has gone into solution, or that stable soluble matter has been partially broken up. In a research on the different actions of sodium peroxide and of permanganate on the organic matter in water (" British Association Reports," 1893), I have shown that different kinds of " albuminoid ammonia " are possible, remarking that waters containing fresh sewage which has been partially oxidised by the peroxide yield the remainder of their ammonia to the alkaline permanganate much more rapidly than when the water had not been so treated, and suggesting the presence in waters of organic nitrogenous matters which, when partially oxidised, are then in a condition to be completely broken up by the stronger reagent. When the albuminoid ammonia process was introduced it was well known that there was a varying relation between the quantities of albuminoid

ammonia and the amounts of different kinds of organic nitrogenous matter. The works of Preusse and Tiemann, Mallet, Leffmann and Bean, P. Frankland and others have confirmed the inference that, although a useful indication, too much importance must not be placed on this item of the analysis.

As a practical test of the effect of dilution with river water in affecting the oxidation of sewage matters, on Nov. 30th I mixed five samples of crude sewage, freed from suspended matter, but smelling very offensively, with a quantity of river water calculated to supply by its dissolved oxygen (100,000 parts of water contain 0.86 parts of oxygen) the quantity of oxygen required by the organic matter, as measured by the " oxygen consumed." One set of samples was kept in the dark, another was fully exposed to daylight, both in contact with air, but protected from dust. The odour rapidly diminished, and in three days all the samples were inodorous except No. 5, which had a faint smell, disappearing in another two days.

After seven days the samples were analysed as to oxygen consumed, nitrates and nitrites:—

PARTS PER 100,000.

Numbers.	Volumes of river water added.	Oxygen consumed of original sewage.	Oxygen consumed in diluted sewage.	Corresponding to oxygen consumed in original.	Nitrogen. as nitrate.	Nitrites.	Per-centage reduction in oxygen consumed.
I. Light.....	6.2	5.34	0.44	2.76	.096	trace	48.3
I. Dark.....	...	...	0.41	2.51	.120	none	53.0
II. Light.....	6.8	5.86	0.22	1.50	.120	faint trace	74.5
II. Dark.....	...	...	0.25	1.67	.144	none	71.5
III. Light.....	7.6	6.59	0.19	1.48	.144	trace	77.5
III. Dark.....	...	...	0.19	1.45	.144	very faint trace	78
IV. Light.....	10.0	8.67	0.13	1.34	.108	none	84.5
IV. Dark.....	...	...	0.16	1.56	.168	none	82
V. Light.....	6.3	5.41	0.22	1.37	.144	none	75
V. Dark.....	...	...	0.21	1.34	.144	none	76

The water used for admixture contained .216 of N as nitrate, no nitrite, and 0.1 " oxygen consumed." Denitrification has evidently occurred, a portion of the oxygen being derived from the nitrate, without production of appreciable nitrite, but the main amount has been supplied by the dissolved oxygen of the river water, the organic matter serving as food to the aerobic bacteria which were acting. The presence of light does not seem to be essential.

The *nitrites* in most cases are indicative of a further stage of improvement, as their production necessarily implies the

disappearance of a greater amount of nitrogenous matter. That of *nitrates*, of course, indicates the final change, and their presence together with free nitrogen in deep well waters, show that denitrification has stopped when the organic matter was consumed.

Many waters are inoffensive which contain a comparatively high amount of albuminoid ammonia. The following, on the other hand, is an example of a putrescent and otherwise objectionable liquid which did not show a corresponding excess of albuminoid. A putrid meat solution was diluted with water in the proportion of 1 to 6,000, and the fluid, which

smelt strongly like sewage, was analysed like an ordinary sewage effluent. It gave in parts per 100,000, free NH_3 '025, albuminoid NH_3 '083; oxygen consumed, '044; no nitrite or nitrate. This liquid remained putrid and foul-smelling for more than a week.

It is obvious, therefore, that an arbitrary standard based upon an albuminoid figure is valueless.

To show how far such conclusions may be carried, Mr. Naylor, of the Ribble Joint Board, has sent me copies of his official reports to that authority, in which I notice for example that on January 7, 1897, an effluent of 150,000 gals. with '101 albuminoid ammonia and 1'95 oxygen consumed was passed as good, but one of 123,000 gals. only, and 1'6 oxygen consumed with an albuminoid ammonia of '108 is only considered fair.

The effective oxidation of the carbonaceous matters is indicated to a great extent by the amount of dissolved carbon dioxide. Free oxygen is absolutely necessary, as the final changes are always aerobic.

Apart from arbitrary standards my experience teaches me that an effluent which is in an active state of self-purification, as judged by the above considerations—if it be clear and nearly free from odour, may safely be discharged into a river of moderate volume. Its subsequent improvement will be very rapid, and will be further determined by the action of algæ and larger plants, in the presence of sunlight, and of the oxygenated water of the river. Percy Frankland, in his paper at the Institute of Civil Engineers, 1897, has said with reference to the Dee, that "each source of pollution was found to have produced an unmistakeable, *though transitory*, effect on the water of the stream." The same transformation has been repeatedly recorded in German and Swiss rivers. Under the above conditions, therefore, of clearness, fair quality, and rapid and healthy change, effected in presence of oxygen by harmless bacteria, we may be considered to have produced a satisfactory effluent.

DISCUSSION.

The CHAIRMAN said the question of the disposal of sewage was one of the most important at the present time, and involved the whole question of keeping our rivers free from pollution and the water fit for drinking. It had been before the public ever since the introduction of the water carriage system, and though no doubt some people still hankered after a

return to earth-closets, he was quite certain that the superior comfort and convenience of water-carried sewage would prevent its abandonment. It had long been known that when sewage was turned into a river, oxidation, aëration, and the action of various plants and animals in the water, would cause a purification of the river at a certain point below the inflow; but it was only since Pasteur explained the action of ferments that the action of bacteria in removing organic matter had been seriously studied. No doubt Lister very soon took advantage of Pasteur's theories to advance the art of surgery in a remarkable manner, but it took a long time before the advantages which could be derived from the action of these minute organisms in the decomposition of effete organic matter in sewage was realised. It should not be forgotten, however, that many years ago Sir Edward Frankland suggested intermittent downward filtration, which had a very valuable effect in assisting in the disposal of sewage. His experiments were followed by those in Massachusetts in 1886, 1887, and 1888; and then Colonel Waring in America adopting the results of those experiments, produced filters which were somewhat of the nature of some of those now being put forward in this country. Then Mr. Scott-Moncrieff suggested his filter, and since that a large number of other filters had been devised. The explanations now given showed that they had at last arrived at a real solution of the question of sewage disposal. Where towns had a large quantity of manufacturing refuse there must be some difficulty in the application of this system, but he was very glad to hear recently that at Yeovil, the sewage of which consisted very largely of manufacturing refuse, these filters were nearly if not quite as successful as they were at Exeter. He hoped, therefore, the time had arrived when we should be freed from any very great difficulty in dealing with the sewage of towns, and freeing our rivers from pollution. They would all agree that this paper showed very clearly the processes which took place, and the directions in which progress should be looked for.

Mr. MARTIN (Exeter) said the question raised by the paper seemed to him more especially of a chemical and biological nature, with which he was not competent to deal, but he had an intimate knowledge of the Exeter works, and might state briefly the results which had been obtained. As had been shown in the paper, amid very great variation of temperature, of season, and of dilution, they uniformly produced an effluent in which the amount of available oxygen was from two to four times the amount required to deal with the organic matter. He had had samples of the filtrate taken under all conditions kept under observation for varying periods—long and short—and they had been kept, not only by them, but by people who were not specially disposed to view the works from a friendly standpoint, and in no case that he knew of had any filtered effluent de-

eloped anything of an offensive character on keeping. Any changes which had taken place had been uniformly for the better. Although they received large quantities of road detritus, which could not be dealt with by bacterial agency, the tank had now been working for about sixteen months, and it had not yet been necessary to clean it out. In something like two and a-half months he had had under observation the behaviour of the effluent from the Yeovil tank on a biological filter. He found it necessary to conduct the experiments with a filter which had been brought into an active condition with the Exeter effluent. The Yeovil effluent was of an excessively foul nature, and on first treating the Exeter filter with it, he found an almost total cessation of nitrification, but after about a fortnight nitrification began and rapidly increased until it reached a point far in excess of anything obtained with the Exeter sewage. He continued the experiment for two and a-half months, and invariably got a very high degree of nitrification. On submitting samples of this filtered effluent to analysis it was found that both the albuminoid and free ammonia were wiped out to an extent far beyond anything attained with the Exeter sewage. Although these works had been spoken of as being of an experimental character, no change had been made in them since the day they commenced. The staple industry of Yeovil was glove making, and in all the processes of dressing and dyeing the leather were carried on there. He had seen the stream into which the refuse passed off all sorts of colours, and very thick. There were also large breweries, and several slaughter-houses. He believed hydrochloric acid and arsenic were used in the treatment of the leather, but was not sure.

Mr. W. NAYLOR thought Dr. Rideal had fallen into the same error with which he had charged him, that of drawing conclusions from insufficient data. He had never advocated the albuminoid ammonia method as a complete test, nor the amount of oxygen absorbed as in itself a complete test; he always used the two. They were not tabulated for various reasons. One was, they were asked to supply the authorities with some sort of table by which they could judge whether the effluent was improving or otherwise, and a table was made out for their guidance; but it was a strictly private account. As Dr. Rideal knew, the ratio between the albuminoid ammonia and the oxygen absorbed varied considerably, and when they were asked to place the effluents in order of merit, it was found better to omit these figures, as sometimes one would have appeared more favourable and sometimes another, and the results could not have been understood, but would have only puzzled those to whom they were submitted. He had hoped to hear something about the cost of this system, because local authorities which had adopted some system of dealing with their sewage did not care much what changes it underwent, what induced them, what per-centage of methane or

carbon dioxide was given off, or whether they were anaerobic or aerobic organisms which did the work. The putrefaction of sewage was not a new idea, although it was referred to as a recent discovery. The same might be said of many other things. The steam-engine had been a long time at work before the theory of it was formulated, and Mr. Bryan Donkin doubted whether it was even yet understood; the same with the chemical theory of the setting of cements, and of many operations in bleaching and dyeing. He had made a pilgrimage to Exeter, the Mecca of sewage sanitarians at present, and it struck him that the essential principle of the septic system was putrefaction—the conversion of the solids into a liquid state; and the question with him was whether the sludge could be got rid of more cheaply in that way than by abstracting it. It appeared to him that in converting the suspended solids into sludge and liquefying it you must throw on the filters four or five times the work they would have to do otherwise, and that consequently the area would have to be increased in like proportion. Thus a local authority having say 2,500 gallons of sewage to treat would have to increase the filter area from say 1,000 yards up to 4,000 or 5,000; there would be 4,000 yards to construct and interest on the cost to be paid, as compared with the cost of abstracting the sludge. The cost of constructing these filters he had heard stated at amounts varying from 10s. to £3 a yard. They must be made so as to last at least thirty years, and to be fairly impervious to outside influences, so that he should imagine £2 a yard would be a fair price. This would mean £8,000 capital outlay, and at 3 per cent., £240 a year, and it was very questionable whether the sludge could not be extracted at a less cost. Then it was contended that the effluent need not be purified to such an extent, and the effluents from Yeovil and Exeter, as evidenced by the analyses presented to the Local Government Board, except those of Dr. Dupré, all contained an amount of organic matter which, until this idea of oxidation by nitrates came up, would have been thought appalling. The question was whether this was a system of sewage purification, or merely of preparation for purification? Was the purification done in the works or in the river? It appeared to him on looking at the equation that x was the purifying agent, but it should be spelt Exe. In large rivers such purification might take place, but his experience on the Ribble and elsewhere did not altogether point in that direction. Six years ago he watched carefully for two days the effluent from Wolverhampton, resulting from tank treatment, and passing over 300 acres of land. It contained nitrates and a considerable quantity of albuminoid ammonia, and a good deal of matter which was left unoxidised; it went into a stream unpolluted by manufacturers, and that stream was not as sweet as it might be; in fact, an injunction was obtained, and a sequestration order made. Another instance was Burnley, where the effluent after passing over 80 acres contained

nitrates, and the river immediately below the works was far from sweet. Most of the rivers flowing into the Ribble were teeming with manufacturers' refuse, which contained large quantities of chlorine, and he questioned whether in such circumstances nitrification would occur; and it must be remembered that the manufacturers had a right to pollute the streams in this way. The Act only prescribed that they should use the best known means to prevent pollution, and no case had yet been taken into Court, in which a manufacturer had been called upon to show that it was reasonable or possible to eliminate any free chlorine, or to keep his sour or weak acids out of the stream. He did not take any prejudiced view of this question, and was now constructing one of Col. Ducat's filters in such a way that it could easily be converted into a septic tank if it should be found desirable. Some two years ago he found the river below Yeovil a seething, bubbling mass, and he lighted several of the bubbles with a match, so that there was evidently not much nitrification taking place, but considerable putrefaction. The river was many times the volume of the sewage.

Mr. GEORGE THUDICHUM desired to endorse Dr. Rideal's statements with regard to the efficiency of the biological treatment. Whether it were done by a septic tank, or a Sutton filter, you got a final filtrate superior to any sewage effluent which had come under his notice in many years. With regard to Exeter and Yeovil, Mr. Dibdin and he had just completed an investigation into the results obtained at Exeter, and that very day they had submitted their report on a similar examination of the Yeovil installation. At Exeter the filtrates were constantly and consistently much better than those from sewage farms. Their average was better than the average from sewage farms; the best results were far above the best from sewage farms, and the worst were nothing like so bad as the worst from a sewage farm. As to the cost at Exeter, a million gallons had to be treated daily, provision being made for the treatment of $2\frac{1}{2}$ million gallons, and the capital sum allotted was £14,000 which included $2\frac{1}{2}$ acres of filters, so that Mr. Naylor's estimate of £2 a yard was very much beyond what Mr. Cameron or Mr. Martin found necessary. At Yeovil they had an extremely foul sewage to deal with, but the resulting filtrate, when the filters were worked on the same plan as that adopted at Exeter, was good. They had been working with an insufficient number of filters, and had consequently been using them for too long a time, and the result was unsatisfactory. They were now treating them similarly to the Exeter or Barking filter, and similarly to the Sutton filter, and the result was a good filtrate. The condition of the river below Yeovil could have nothing to do with the filtrate from the septic tank, as the Yeovil sewage was about 500,000 gallons, and the septic tank had only been treating 10,000 gallons a day. He could not agree with Dr. Rideal that the idea of purifying sewage by other than chemical processes was quite recent, because in

1886, in that room, Dr. Tidy read a paper on the subject, and Dr. Dupré told the meeting that in his belief the ultimate purification of sewage depended solely on the action of micro-organisms. As had been pointed out by the Chairman, it had been recognised by Sir Edward Frankland and others, and publicly stated by Mr. Dibdin in 1887. Again, it was stated that the breaking down of the solids without oxygen was an essential preliminary; but if so, how came it that in the experiments of Dr. Dupré crude sewage was put into a sufficient volume of fully-aerated water and purified without passing through any visible or perceptible stage of putrefaction? He knew that on some of these points Dr. Rideal and he were not in accord. Dr. Rideal considered that the Sutton bacteria bed was a septic tank acting anaerobically, although under aerobic conditions; but, in his opinion, that contention could not be sustained. The bed was not worked continuously, but intermittently; it took from 40 minutes to an hour to charge, stood 2 hours, was then emptied, and remained empty and full of air for a period which would complete the cycle in from 8 to 10 hours. He could not consider that anaerobic treatment. Again, it was said that Col. Ducat's filter was the same as the Sutton, with the coarse part placed on the top of the fine, but that was not so, because Colonel Ducat worked continuously according to the Massachusetts method, pouring the water over surfaces in the presence of air. With regard to the ratio of nitric oxygen to the oxygen absorbed by the organic matter being the test of the safety of the effluent, he was still of opinion that this could not be accepted as a test; anyhow, the nitrate present must be derived from the organic matter and could not be added nitrate. He had proved that in many experiments on London sewage, where the addition of as much as 20 grains of nitrate per gallon did not prevent the putrefaction of sewage. He looked on the presence of nitrates derived from the original organic matter, not as indicating the amount of oxygen available for the rest of the organic matter, but as indicating that the whole organic matter present had undergone such a change that putrefaction in ordinary circumstances could not occur because the stage in which it could so occur had passed. He should agree that if ever there were a large excess of nitrates it was a good effluent, but he did not agree on the interpretation to be placed on their presence. With regard to the experiment in which Dr. Rideal placed clear but foul sewage into quantities of water, determined according to his formula, he would point out that although he only supplied them with the oxygen already dissolved in the water, he had omitted to notice the fact that as fast as the dissolved oxygen was taken up by the organisms for oxidation of the organic matter, that oxygen, or some of it, was re-absorbed from the atmosphere. It had been shown by Mr. Dibdin and himself in the course of an exhaustive series of experiments that the rate at which water

absorbed oxygen from the air varied inversely with the degree of aëration. When the water contained no oxygen it absorbed it at an infinite rate; when saturated, it absorbed none. As the degree of aëration was diminished by the quantity of organic matter present the rate at which it took oxygen from the air increased until the two rates balanced each other, and that was the condition in the Thames at present. When the rate of absorption was never below 50 per cent. of the total possible aëration, fish would exist and thrive; so long as the degree of aëration exceeded 20 per cent. of saturation, at which point the rate of re-absorption was enormous, fish could not live, but wholesale putrefaction such as was seen in the Thames in 1884 and 1887 could not take place; when the organic matter was in such excess that it brought the degree of aëration below 20 per cent. of the possible; then, although the rate of re-absorption was approaching the infinite, the river could not cope with it. The experiments described by Dr. Rideal, to be of value, must be made in hermetically sealed bottles. Dr. Dupré had made such a test, and found that for London sewage it required from 10 to 35 volumes of fully aërated London tap water, which was a very different figure to the 6 or 8 derived from the formula.

Dr. RIDEAL, in reply, said he had not gone so much into a discussion of filters as the general principles of the process. It was strange that these methods of filtration had only recently been introduced, and he pointed out that this was due to the preliminary breaking down under anaerobic conditions having been overlooked in the early experiments. Although Mr. Thudichum contended that it was not an anaerobic change which took place in the coarse filter, it seemed to him it must be so in the first instance. Although the organic matter was surrounded with oxygen, and although the filter was aërated, the first change was the conversion of the solid into the liquid condition, which could take place without any oxygen. Therefore, in the Sutton coarse filter, though aerobic, a good deal of nitric acid being formed in the tank, the initial change was anaerobic in spite of the aerobic conditions. With regard to Mr. Naylor's remarks, he might say that he did not come there to advocate the septic tank or any other system; he wished to draw attention to these three or four different methods. When at Exeter a fortnight ago he certainly advocated the Exeter system for Exeter, but he had no interest in it whatever. The Exeter Town Council called him in and he advised them with regard to it, and he should think Mr. Naylor would have no difficulty in getting information as to the merits of the different systems as adapted to his peculiar circumstances. The question of cost was one which he had not considered at all in preparing the paper. He did not agree that the idea of measuring the value of an effluent by the amount of nitrate was a new one, which could be put before the albuminoid ammonia and oxygen consumed simply

that it might fit in with this newer system. The same thing was true with regard to a sewage farm effluent; it was not satisfactory, whatever its albuminoid ammonia was, if it had not a quantity of nitrate, which showed that the nitrification process had been in active progress and that oxidation was getting towards completion. It was not the absolute amount of organic matter present in an effluent which ought to be considered so much as whether the organic matter was in a condition to cause a nuisance. If it were run into a large river, full of dissolved oxygen, or with a large quantity of nitrates, or if you introduced bleaching powder, or permanganate, or some oxidising agent, then, notwithstanding a high albuminoid figure, the liquid could not cause a nuisance. You had potential oxygen there which was sufficient to prevent the effluent undergoing change. Mr. Thudichum said he would only agree with him so far, that if the nitrate were already present, he would pass the effluent; but from his experience at Barking, he must have often discharged into the Thames an effluent to which permanganate or some other oxidising agent had been added, in order that it might not putrefy. He believed that Mr. Adeney had also given evidence that the addition of artificial nitrates to an effluent would prevent its putrefying. At any rate, if the addition of manganates would prevent putrefaction, it seemed quite possible that nitrates would equally prevent it. But he had not raised that point at all; he had been dealing simply with the effluents as they came from filter beds or sewage farms, and in those cases there could be no doubt that nitrates had been produced by nitrifying organisms. It must also be recollected that he only contended that nitrates would reduce the organic matter when denitrifying organisms were present; there was no evidence to show that they were present in Mr. Thudichum's experiment. The phrase "quite recently" was only meant to apply to the recognition of the differentiation between the preliminary breaking down, which did not involve oxidation, and the subsequent oxidation which was now sufficiently understood after the long course of experiments carried out at Barking, in Massachusetts, and elsewhere.

The CHAIRMAN proposed a vote of thanks to Dr. Rideal, which was carried unanimously.

Miscellaneous.

SILK & COTTON INDUSTRIES OF ITALY.

The value of the exports of silk textiles from Italy, estimated at £1,120,322 for the year 1895, stamps the silk industry as one of the most important in the country, and as evidence of its rapid development, it may be mentioned that whereas in 1887 the excess of imports over exports of silk textiles was 7,778 cwts., in 1894 the situation was reversed, and there was an

excess of exports over imports of 2,783 cwts. The value of silk textiles annually manufactured is said to have doubled in the last ten years, and to amount now to about 90,000,000 lire, or approximately £3,600,000. Mr. E. FitzGerald Law, Commercial Secretary for Italy, says in his last report that the quantity of cocoons worked up in that country is indicated by the following figures for the year 1894:—Production, 868,766 cwts.; importation, 27,272 cwts.; exportation, 4,482 cwts.; leaving a balance of 891,556 cwts. for consumption in the country. It is estimated that 12 lbs. of cocoons yield one pound of raw silk. According to the *Annali di Statistica*, in 1890, 11,618 horse-power derived from steam, and 4,802 horse-power from water, were employed in the working of silk, and there were 1,534,849 spindles and 14,949 looms at work. Of the looms, 12,414 were hand looms. About 172,000 hands were employed, of whom about nine-tenths were women and children. The silk industry in different forms is to be found in nearly all parts of the kingdom, but in Sicily and the southern continental provinces it is chiefly confined to reeling and spinning, while in the north, and particularly in Lombardy, there are many large establishments using the best machinery for weaving and dyeing. Como is one of the most important centres of the industry, and there, as in most other places, the majority of the woman workers come from the neighbouring villages; they work six days of the week and go home on Saturday evenings, to return to the mill on Sunday night. Ten to eleven hours per diem appear to be the usual working day. The industry is said to be a healthy one. At a large reeling establishment in Messina, the average wage of reelers is about 10d. a day; of brushers, about 5½d.; and of children, 3d. At this establishment, and in general in the south, the working day is very long, extending to a maximum of 12 hours in summer, though shorter in winter. Near Milan, in a large weaving establishment, where 1,800 hands are employed, women weavers earn from 1s. 3d. to 1s. 8d. per diem, working 11 hours. In a dye works at Como, employing 800 hands, men earn from 2s. 6d. to 3s. per diem, and women, 1s. 3d., working ten hours per diem. In Florence, women working piece-work at hand looms earn, on an average, 1s. to 1s. 3d. per day of 10½ hours. The best hands earn up to 1s. 8d. per diem. In silk textiles, chiefly the cheaper qualities are produced. A very large trade is done in umbrella coverings, which are mostly shipped to London. England and the United States are the most important markets to which Italian silk manufactures are exported. The cotton industry is perhaps not as important as the various combined branches of the silk industry, the latter being specially favoured by the large production of silk in the country. There is a certain production of cotton in the south of Italy, but the quantity produced is comparatively insignificant. The importation, is however, very large, over 100,000 tons having been imported in 1895, and a still larger quantity in the previous year. The manu-

facture of both yarns and textiles is rapidly increasing as is shown by the figures of exports during the last few years. Taking the period 1884-1894, it is found that the importation of cotton yarns in 1884 was 196,718 cwts., and the exportation 3,427 cwts.; in 1894 the importation was 20,455 cwts., and the exportation 22,142 cwts. The importation of cotton textiles in 1884 was 258,867 cwts., and the exportation 74,296 cwts.; in 1895 the importation was 75,665 cwts.; and the exportation 96,897 cwts. The value of all cotton manufactures in 1895 was calculated at about £12,000,000, as compared with about £7,200,000 in 1884. It was estimated in 1894 that there were about 1,300,000 spindles in the cotton mills in Italy, and that about 82,000 hands were employed, but there has been a considerable increase in the last two years. The spinning and weaving industries have long since attained very considerable development, and lately printing and finishing have specially attracted the attention of manufacturers, and printing machinery is being erected in both old and new mills. Spinning and weaving machinery comes almost entirely from England, while most of the machinery for printing and finishing is imported from Germany and Switzerland. The medium number in spinning is 12, and 32 appears to be about the finest. The chief seat of the cotton industry is in the northern provinces, and particularly in Lombardy, Piedmont, and Liguria. There are also some important establishments in Campania, Venice, and Tuscany. In the north, most of the cotton mills work day and night with only one hour's interval for rest and food. In the north, women's wages appear to average about 1s. 4d. to 1s. 6d. per diem; in Tuscany, 1s. 5d.; in the neighbourhood of Naples, 1s. 3d., and at Salerno only 7d. Men's wages vary from 1s. 4d. per diem in Salerno, to 2s. in Tuscany and the north. In addition to money wages, however, the hands almost always enjoy some privileges, either in the form of cheap lodging or cheap food, or both. In the neighbourhood of Naples, however, there is practically no addition to the bare money wage. An interesting calculation has been made, comparing the results and costs of English and Italian labour in cotton spinning. It is estimated that in Italy it takes 58.4 hours of labour, costing 5s., to produce 220lbs. (100 kilogrammes) of yarn; while in England it is assumed to take 29.3 hours, costing 5s. 6d., to do the same work. The number of hands employed in Italy would be 12, and in England 7½. This estimate is not accepted by all Italian cotton masters, one of the most intelligent of whom, says Mr. Law, assured him that, allowing for the greater number of hours worked per diem, an Italian operative would produce as much as an English one. It has also been asserted that coarse cloth can be produced as cheaply in Italy as in England, and the export figures prove conclusively that there are certain foreign markets in which the Italian manufacturer can compete successfully. Apart from the question of labour it is, however, generally admitted that the Italian spinner is under

considerable disadvantage as compared with his English competitor. The heavy rate of taxation in Italy, the cost of fuel, the comparatively high rate of interest on capital, and the high price of imported machinery, all tell against the Italian manufacturer, and, in addition to these direct drawbacks, he is obliged to employ a larger staff, and to lock up considerable sums in the commercial department of his business. Large fortunes were made by the pioneers of the cotton industry in Lombardy, but competition has now reduced profits to a very moderate scale. On the whole, however, well-conducted establishments appear to be generally flourishing. Sewing cotton is manufactured in Italy, but not to any very great extent, and the number of mills is small. The most important establishment is in the neighbourhood of Lucca, where 600 hands are employed, and the value of the annual production is estimated at about £80,000.

AGRICULTURAL EDUCATION IN FRANCE.

In France, schools of agriculture have long existed, and, like so many other useful movements, can be traced back to Sully. In 1761 the "Société Nationale d'Agriculture de la Généralité de Paris" (now the "Société Nationale d'Agriculture") came into existence and agitated for the appointment of agricultural professors. Various large landed proprietors established small schools of agriculture, and Louis XIV. in 1786 founded an experimental farm and sheep fold at Rambouillet and introduced the breeding of Spanish Merinos. Within the last few years, however, agricultural education has been systematised and extended to all classes of the population engaged in agriculture. The Commercial Attaché to the Embassy at Paris states that the Agronomic Institute in Paris gives the highest scientific instruction, and has a staff of agriculturists capable of giving a new and forcible impulse to agriculture. There are also three veterinary schools of the same standing, and three national agricultural schools in which the theory and practice of agriculture are taught to the sons of the large landowners and farmers, as well as a school of horticulture, a dairy school, and one of agricultural industries (sugar making, distilling, brewing, &c.), a school of horse-breeding, a school of forestry, and three secondary schools of forestry. These schools belong to the State. Schools of practical agriculture exist in various parts of the country, and vary according to the principal cultivation of the district in which they are established. They are open to the children of peasants, farmers, and landowners on their leaving the primary schools. They consist of 24 schools of general agriculture, 2 schools of irrigation and drainage, 5 of southern and Algerian cultivation, 4 of vine culture, 5 of dairy and cheese-making, 2 of dairying for girls, and 1 of poultry farming. They do not belong to the State, but are carried on at the risk of the founders. The State, however, contributes the funds

necessary for the teaching, and they are visited by Government inspectors. The fees payable by the pupils vary according to the district, being for boarders from £16 to £24 per annum, for half-boarders from £8 to £10, and for day pupils about £2. For the humbler classes there are apprentice schools, comprising 16 farm schools, 2 sheep schools, 1 silkworm rearing school, 14 milk and cheese schools, 1 fish-breeding school, and 2 primary agricultural schools. The instruction in these schools is entirely practical. They belong to private persons, but the State pays for the teaching, and allows £10 16s. per annum for each apprentice. The education is gratuitous. The Government inspector visits these schools. A law passed in June, 1879, renders instruction in agriculture compulsory in all training schools for teachers, so that they may be enabled to impart a knowledge of the subject to the children in the primary schools of all rural communes. The teaching of agriculture became compulsory in these schools in 1882. Agricultural education is also given by the 90 occupants of departmental "Chairs of Agriculture" organised by the State, who, by lectures in the principal rural communes, make known the most important discoveries and the surest means of increasing agricultural production. They are assisted in this task by 116 professors of agriculture, who give lectures in summer on Sundays, and in the winter in the evenings. Agricultural chairs have also been created in public educational establishments in rural districts to enable the pupils to follow a course of agricultural instruction at the same time that their general education is proceeding. In addition to the above-mentioned educational arrangements, there are 78 establishments for agricultural research. These comprise 60 agronomic stations and laboratories, four agricultural stations, two silkworm stations, two entomological stations, two stations for vegetable physiology and one each for testing seeds, vegetable pathology, animal physiology and nourishment of animals, trial of machines, study of ferments, and study of the vine. Nearly every department possesses fields for experiments and demonstrations, the expenses being borne by the State and the Department jointly. With the ample facilities thus afforded to all classes of the rural population to receive a professional education, with the improved culture of the soil, and with the large increase in the use of fertilisers, it is not surprising that agricultural production in France has increased so largely. The value of agricultural land in France is stated to be £3,200,000,000, while the working capital is £340,000,000; the amount of wages paid to farm labourers amounting to £160,000,000, and the value of the produce to over £540,000,000. The total number of the population living by agriculture (farmers, labourers, and their respective families) is estimated at 18,250,000 souls, or about one half the total population of France. The agricultural classes are divided into two nearly equal groups, the masters being reckoned at 3,460,600, whilst of the labourers there are 3,452,904.

THE FINE ARTS IN HUNGARY.

In the domain of the fine arts, Hungary may well be proud to have created for herself by hard work within the space of a few decades, a public artistic life of her own, which is inspired by the example of the King and encouraged by the annual purchases of works of art made by the Government for the national museum. The aristocracy and the rich merchants are likewise ready patrons of artistic productions. Her Majesty's Consul-General at Buda-Pesth says that among the works produced during the past 25 years are some large and fine frescoes in the Cathedral of Pecs, and in the Opera House and the St. Matthias Church at Buda-Pesth. In oil painting it suffices to mention the names of Munkácsy Benczur for portraits and Charles Markó for landscapes. The art of engraving has also several eminent representatives. Sculpture has not as yet attained a very high standard, but architecture is in a flourishing condition. There is indeed a whole generation of sculptors in the service of Hungarian art, and the capital already possesses a series of monumental effigies of martyrs, patriots, archdukes, statesmen, poets, &c., and the King has announced that it is his intention to present ten new statues of former Hungarian celebrities to the city. As a really modern town, Buda-Pesth causes astonishment and admiration by the great quantity of fine public buildings which it contains, and a numerous band of architects find occupation owing to the surprisingly rapid development of the capital. There is no attempt made at uniformity of style or design, but the results are successful in diverse directions, and generally pleasing to the eye. The new Houses of Parliament by Strindl, now approaching completion, are particularly worthy of notice. Industrial art education is provided for by several institutions, such as the Public Industrial Art School at Buda-Pesth, and the Royal Hungarian Art Industry School, the Technological Museum, and the Industrial Art Museum. In the production of porcelain and majolica success has always been gained, and in every branch of industrial art there is a good prospect of future prosperity.

THE INDUSTRIES OF JAPAN.

Agriculture is the chief pursuit of the people of Japan, and in the greater part of the cultivated area rice and the principal food crops, wheat, barley, and soya beans are grown. Mulberry trees are planted everywhere. Tea is mainly cultivated in the south of Honshiu and in Taiwan, Formosa. The mineral wealth of the empire is great, but much improvement is needed in mining. The coal production is rapidly increasing, especially in Kinshiu and Hokkaido. The development of the iron industry is somewhat slow, but much is hoped for in the future. The production of silver has been steadily rising; copper and antimony are also among the principal exports of the country.

The industries of the Japanese Empire may be distinguished as "original" and "imported." The original industries which existed from early times are those of ceramics, weaving, embroideries, lacquer work, paper, metals, leather, wood and bamboo carvings, camphor, vegetable wax, salt, sugar, saké, soy, oil, tobacco, indigo, and raw silk. These industries seem to have been first introduced from Corea or China, but the lapse of several hundred years has obliterated the original traces. Their scope of working is generally small, and the tools and instruments used are rude and simple. The industries which have been introduced into the country are those lately brought over from Europe and America. These comprise cotton spinning, brickmaking, preparation of drugs and chemicals, cement works, wiremaking, woollen manufacture, shipbuilding, and machinery, match, paper, and soap making. These industries are generally carried on on a large scale, employing a vast number of workmen and using water and steam power. According to the latest returns the total number of factories belonging to companies and individuals is 5,985, 1,098 of these being provided with steam engines, and 221 with both steam and hydraulic engines.

General Notes.

NEW ZEALAND MUTTON.—It is expected that this last month of the year will be chronicled in the New Zealand mutton trade as the one during which a larger number of carcasses arrived in London than in any other month since the trade started for by the end of the year December arrivals will probably be about 410,000 carcasses. Notwithstanding the heavy stocks a slightly better tone is said to prevail which may reasonably be ascribed to the advance in values of Australian and Plate sheep. The prices for the best grades of prime North Canterbury are inclined to be firmer.

MEETINGS FOR THE ENSUING WEEK.

- MONDAY, DEC. 20. Imperial Inst., South Kensington, 8½ p.m. Mr. Boverton Redwood, "The Petroleum Sources of the British Empire."
Actuaries, Staples-inn-hall, Holborn, 7 p.m.
East India Association, Westminster Town-hall, S.W., 4 p.m. Mr. C. L. Tupper, "Early Institutions and Panjab Tribal Law."
- TUESDAY, DEC. 21 ... Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. W. E. Dalby, "A New Transmission Dynamometer."
Pathological, 20, Hanover-square, W., 8½ p.m.
Photographic, 12, Hanover-square, W., 8 p.m. Col. Waterhouse, "Photomechanical Printing in connection with the Survey of India."
- THURSDAY, DEC. 23. ... Geographical Association (at the House of the Society of Arts), 4½ p.m. Dr. H. R. Mill, "Some Hints on teaching Geography."

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FRIDAY, DECEMBER 24, 1897.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****JUVENILE LECTURES.**

The usual short course of lectures adapted for a juvenile audience will be given on Wednesday evenings, January 5 and 12, 1898, by Professor WILLIAM RAMSAY, Ph.D., F.R.S., on "Fire."

The lectures will commence at 7 o'clock. Special tickets are required for these lectures, which can be obtained on application to the Secretary. A sufficient number of tickets to fill the room will be issued to members in the order in which applications are received, and the issue will then be discontinued. Subject to these conditions, each member is entitled to a ticket admitting two children and an adult. The cards are now in course of issue, and it is desirable that those requiring them should apply at once.

LIST OF MEMBERS.

The new edition of the List of Members of the Society is now ready, and can be obtained by Members on application to the Secretary.

Proceedings of the Society.**CANTOR LECTURES.****GUTTA PERCHA.**

BY DR. EUGENE F. A. OBACH,
F.I.C., F.C.S., M.I.E.E.

Lecture I.—Delivered November 29, 1897.

THE RAW MATERIAL.—The year 1847—Early history and the Society of Arts—General properties and distinction from caoutchouc—Botanical derivation—Geographical distribution—Expeditions in search of gutta trees—Experimental distillation—Analysis of particular specimens—Analysis of various commercial brands—Exports from Singapore—Imports into the United Kingdom—Fluctuation of prices.

THE YEAR 1847.

The year 1847 will ever remain a memorable one in the annals of the gutta percha industry.

It was in that year that the plant from which this valuable economic product is derived was first named and illustrated by Sir William Jackson Hooker,¹ the famous director of the Royal Gardens at Kew, and during the same year that Dr. Ernst Werner von Siemens,² then a lieutenant of artillery in the Prussian army, employed gutta percha for the electric insulation of subterranean telegraph lines, and designed a machine by means of which wire could be continuously covered with this material. This, with but slight modifications, is still in use at the present day.

The Society of Arts having from the very first taken a keen interest in the welfare of the gutta percha industry, it was considered opportune to devote the opening course of Cantor lectures of the present session to a consideration of this subject, and to survey the progress made during the fifty years of existence of this industry.

It is not, however, the first time that gutta percha forms the subject of a Cantor lecture. In February and March, 1880, Mr. Thomas Bolas³ delivered a course of six lectures on "The Indiarubber and Gutta Percha Industries" before this Society, which, I well remember, were greatly appreciated by those who had the privilege of hearing them. Mr. Bolas, however, was only able to devote a single evening to gutta percha, and considering the far greater importance and complexity of the rubber industry, this was perfectly justifiable, but I imagine he must have felt a little embarrassed in having to compress the whole subject into so small a compass. For this reason, and owing to the liberality of our esteemed Chairman to-night, Mr. Alexander Siemens, in allowing me to lay before you the results of various experimental researches carried out by me in the laboratory of Messrs. Siemens Bros. and Co. during the last twenty years, which have not hitherto been described, I was emboldened to recur to this subject and to devote three entire evenings to its consideration. In doing so, I am fully aware that the exaggerated expectations which were held when gutta percha was first brought to the notice of the technical world were not fully realised, yet there are even at the present

¹ "Botanical character of a new plant (Isonandra Gutta) yielding the gutta percha of commerce." By W. J. H. *The London Journal of Botany*, 1847, vol. 6, p. 463.*

² "German experiments on the insulating properties of gutta percha covered electric wires." By Mr. Werner Siemens. *The Mechanics' Magazine*, 1849, vol. 50, p. 99.*

³ *Journal of the Society of Arts*, 1880, vol. 28, pp. 75, 763, 773, 783, 793, 803.*

day certain important applications of this material for which it is well-nigh indispensable, and in which no other hitherto known substance, not even the closely related caoutchouc can take its place. Amongst these, let me now only remind you of the most important one, viz., the manufacture of submarine telegraph cables, without which the immense progress of the last 45 years would have been quite impossible.

In preparing these lectures, I endeavoured to do equal justice to the various aspects of the subject, and to amalgamate the results of scientific research with those of practical experience, since it is my firm belief that no industry can continue to prosper without the aid of scientific research.

EARLY HISTORY AND THE SOCIETY OF ARTS.

The early history of our subject is not without its charm; and, although I may not perhaps be able to contribute much towards it which is entirely novel, yet I venture to hope that the brief historical account I am able to give you to-night will be of some interest, inasmuch as I obtained my information first-hand from original sources,¹ which, as you all know, are sometimes difficult to procure.

It appears that the first specimen of gutta percha was brought to Europe by those indefatigable travellers and curiosity-hunters, the Tradescants, father and son, about the middle of the seventeenth century. In a little book, by John Tradescant, the younger, entitled *Musæum Tradescantianum, or a Collection of Rarities preserved at South Lambeth, near London*, published in 1656, which I hold in my hand, there occurs (p. 44), amongst a list of various "rarities," such as an "Indian fiddle," "Birds' nests from China," "Blood that rained in the Isle of Wight," &c., the following interesting object, viz., "*The plyable Mazer wood, being warmed in water, will work to any form.*" This is considered to apply to gutta percha,² since we know of no other material suitable for mazers or goblets, which possesses the remarkable property of softening in warm water, so that it can be worked into any desired shape or form as here

stated. At first it may perhaps appear strange that this material should be described as "wood," but, after all, it is not so very surprising, if it be considered that gutta percha as formerly prepared by the natives, was of a light yellowish-brown colour, much resembling that of many varieties of wood, and also showed a decidedly fibrous texture, so that even an experienced observer has been led astray, as I shall be able to prove to you later on.

On the death of the younger Tradescant, in 1662, the "Collection of Rarities" came into the possession of the famous Elias Ashmole, who transferred it to Oxford, where it formed the nucleus of the Ashmolean Museum, opened in 1683. I thought it might perhaps be possible to ascertain what finally became of the specimen of *mazer wood* there, but I am informed by the assistant-keeper of the Ashmolean Museum that it is now neither at that museum nor at the Botanic-garden at Oxford.

Through the courtesy of a friend at the British Museum, I am able to show you on the screen to-night the portraits of the two Tradescants, which were taken from engravings by their celebrated contemporary and friend Wentzel Hollar, and contained in the little book I mentioned. My own copy has unfortunately been deprived of these valuable engravings by one of the "Hollar" collectors—indeed, almost every copy of this rare book had been plundered of them already in the middle of the last century.¹

Although the "Tradescant's Ark," as the museum was popularly called, "attracted the curiosity of the age, and was much frequented by the great," including amongst its benefactors even King Charles and the Queen, yet it appears that the remarkable properties of the "mazer wood" passed quite unnoticed by practical men, and the specimen was considered merely a "rarity," as was the wont of the age. It was reserved for our own century, so prominent by its practical application of every available product, to re-discover the valuable substance and to apply it in the arts and manufactures under the name of *gutta percha*. Curiously enough in the year 1843 there appeared two rival claimants for the honour of re-introducing this material into Europe, both residents of Singapore and both belonging

¹ The quotations marked by an asterisk (*) are taken directly from the source thus marked.

² The first reference thereto appears to be that by Robert Ellis in the Official Catalogue of the Great Exhibition of 1851, vol. 2, p. 784.* This opinion is also shared by Dr. Sheridan Muspratt in his well-known work on Chemistry, vol. 2, p. 349,* and by Mr. James Collins in his article on Gutta Percha in the "Encyclopædia Britannica," 9th edition, 1880, vol. 11, p. 338.*

¹ "Some Account of the Remains of John Tradescant's Garden at Lambeth," by Mr. W. Watson, F.R.S., Transactions of the Royal Society, 1749, vol. 46, p. 160; Abridgement 1809, vol. 9, p. 658.* This paper also gives some biographical notices of the Tradescants. An oil painting of the younger Tradescant is now in the National Portrait Gallery.

the medical profession. The one, evidently of Spanish descent, Dr. José D'Almeida, brought specimens with him to London in the spring of that year and presented them to the Royal Asiatic Society; the other of Scottish descent, Dr. William Montgomerie, sent samples to the Society of Arts, through his brother-in-law, Mr. H. Gouger, during the summer of that year. Dr. D'Almeida's specimens are described¹ as consisting of "a riding whip, made of the concrete milk of a tree indigenous in Singapore, called *gutta percha* by the Malays, also a specimen of the concrete milk in the lump," the remark being made that "*it becomes ductile by being placed in hot water.*" Dr. Montgomerie's specimens² consisted of the following:—"One bottle of the juice; specimens of thin sheets, resembling scraps of leather; specimens in a spongy mass as it concretes in a vessel; specimens of the substance formed into a mass by agglutinating the thin sheets by means of hot water." The secretary of the Royal Asiatic Society acknowledged the receipt of the specimens in a letter dated April 8th, 1843,³ and handed a portion of the raw material to Dr. J. F. Royle for analysis,⁴ D'Almeida himself having previously given a piece of it to Mr. W. C. Crane⁵ for the same purpose. It appears, however, that neither of these gentlemen made any experiments with the material, and no immediate practical result followed from submitting the specimens to the Asiatic Society. Luckily such was not the case with the specimens sent to the Society of Arts. In a meeting held on November 30th, 1843, and therefore just 54 years ago to-morrow, the Joint Committee of Chemistry, Colonies, and Trade "took into consideration specimens of a substance called '*gutta percha*,' from Singapore, sent to the Society by Dr. Montgomerie," and at a subsequent committee meeting, held on January 23rd, 1845, with Professor E. Solly in the chair, it

was resolved "that this substance appears to be a very valuable article, and might be employed with great advantage in many of the arts and manufactures of the country."¹ At an ordinary weekly meeting on March 19th, 1845, the secretary, Mr. Francis Whishaw, described the specimens, and showed a piece of pipe and a lathe band of *gutta percha*, made by him, which were afterwards exhibited at the Great Exhibition of 1851;² he also covered the bottle, which originally contained the "milky juice" with *gutta percha* softened in hot water, and produced some good impressions of medals. It was at this meeting that Mr. Christopher Nickols first became acquainted with *gutta percha*, and was so impressed with its valuable properties, that he induced Messrs. Wilkinson and Jewesbury, a firm doing business with Singapore, to import a small quantity for experimental purposes.³ It was also evidently at that same meeting that Mr. (afterwards Sir) William Siemens, became acquainted with the new material, and obtained the sample which he subsequently sent to his brother Werner in Berlin, to try whether it was suitable for insulating telegraph wires, a proposal which has had such far-reaching consequences.⁴

The Society of Arts having thus early recognised the great practical importance of Dr. Montgomerie's discovery, it was not surprising that on June 2, 1845, it awarded him its gold medal.⁵ This act on the part of our Society has been severely criticised, and it was blamed for rewarding Montgomerie and passing over D'Almeida,⁶ whose services in rediscovering *gutta percha* were said to be equally great; but not only did the last-named gentleman address his specimens to a totally different society, he was also behind his rival in point of time, inasmuch as Dr. Montgomerie had

¹ From the Minute Book of the Society.

² *Offic. Catal. Great Exh. 1851. Class 10, No. 419. Vol. 1, p. 455.**

³ H. W. Jewesbury. "A Short History of the Introduction of Gutta Percha into Europe." London 1883, p. 9.*

⁴ C. W. Siemens. *Journal of the Society of Telegraph Engineers*, 1876, vol. 5, p. 82.* Dr. Siemens thought it was Montgomerie who gave him the sample at the Society of Arts, but it was probably Mr. Henry Gouger or the secretary, Mr. Whishaw, as there is no record in the Minute Book that Dr. Montgomerie ever attended any of the meetings.

⁵ The original medal having been handed to the lecturer by Miss Montgomerie, it was shown to the audience.

⁶ Thos. Oxley, *Journ. Ind. Archip.*, 1847, vol. 1, p. 22; A. A. Lackersteen, *Mech. Mag.*, 1847, vol. 46, p. 474; Don José D'Almeida, the son, *Journ. Soc. Arts*, 1838, vol. 7, p. 20.*

¹ *Journal of the Royal Asiatic Society*, 1844, vol. 8, p. xv.* List of donations to the Museum from April, 1842, to June, 1844.

² Extracts from the Minute Book of the Society of Arts. Minutes of the Joint Committee of Chemistry, Colonies, and Trade.)

³ *Vide*: Mr. A. A. Lackersteen's letter to the Editor of the *Mechanics' Magazine*, dated May 12th, 1847. *Mech. Mag.*, 1847, vol. 46, p. 474.*

⁴ *Vide*: Mr. William Neal's letter of September 3rd, 1858, written in the name of the Secretary of the Royal Asiatic Soc., *Journ. Soc. Arts*, 1858, vol. 7, p. 21.*

⁵ *Vide*: D'Almeida's memorandum to the Editor of the *Journal of the Indian Archipelago and Eastern Asia*, 1847, vol. 1, p. 78.*

already submitted samples of gutta percha¹ to the Bengal Medical Board previous to those forwarded to London. These specimens were accompanied by a letter, dated March 1, 1843, which shows without a doubt that Montgomerie had already then personally acquainted himself with the principal properties of the new material and ascertained its suitability for surgical instruments, and its superiority over caoutchouc for that purpose in tropical climates. This letter, together with some of the specimens, was sent to the Agricultural and Horticultural Society of India for publication by Dr. Fred. Mouat,² Chemical Examiner to the Government at Calcutta, and, as it forms the first published record referring to gutta percha, after the more or less apocryphal quotation in the Tradescant catalogue, it is of great historical interest, and will be reprinted in an *Appendix* to these Lectures.

The specimens submitted to our Society were likewise accompanied by a memorandum from Dr. Montgomerie in which he makes similar remarks³, and on October 26, 1846, he wrote to the editor of the *Mechanics' Magazine*⁴ entering more fully into the early history of the subject. He states that he first became acquainted with gutta percha in 1822, when he acted as assistant surgeon to the Presidency in Singapore, but lost sight of it until in 1842 he noticed in the hands of a Malay woodman, a parang (wood chopper) the handle of which consisted of a substance which appeared new to him. His curiosity was still further aroused when he learnt that the material had the remarkable property of becoming soft and plastic like clay in boiling water, and he at once possessed himself of the article and asked the Malay to procure as much of this substance as he possibly could. Dr. Montgomerie's communication to the *Mechanics' Magazine* was followed by an able contribution from the pen of his successor in office, Senior Surgeon Dr. Thomas Oxley, to the first number of the *Journal of the Indian Archipelago and Eastern Asia*, which appeared in July, 1847.⁵ In this article Dr. Oxley gives an interesting

general description of the gutta percha tree its leaves, blossoms, &c.—the fruit he had not seen¹—and describes the way in which the gutta percha is obtained from it. He also recommends the use of this substance for surgical appliances such as bandages, splints, syringes capsules for vaccine virus, &c.; but I must not go any further into details, as I shall have occasion later on to recur to this interesting article in connection with other subjects, and will now say a few more words about the connection of the Society of Arts with the development of the gutta percha industry.

The interest taken by the Society in this matter by no means ended after rewarding the gentleman who first introduced the material to its notice, and we find that in October, 1854, a premium was offered for the discovery and production to the Society of any new substance which could be successfully employed as a substitute for gutta percha,² and in November 1863, the Society's medal was again offered "for any new substance or compound which may be employed as a substitute for india rubber or gutta percha in the arts and manufactures."³

On February 24th, 1858, the Council of the Society appointed a Committee "to direct the institution of a series of experiments on gutta percha, and to report from time to time such observations as may appear to elucidate the nature and cause of its decay, the different qualities of the substance, modes of detecting adulterations, or any points valuable to the manufacturer or to those who use it."⁴ This committee included amongst its members such well-known scientific men and technical experts as Prof. Edward Solly, Prof. John Lindley, Sir William Siemens, Mr. Latimer Clark, Mr. Edward Highton, and others. After the committee had met several times, a circular was issued containing a number of questions with a view of obtaining as much information as possible from those able to give it outside the Society. Some of these questions have since been answered satisfactorily, but others remain unanswered up to the present day.⁵

¹ Some of these specimens were sent to the Great Exhibition of 1851 by Col. Bonner, of the East India House. *Offic. Catal.*, vol. 2, p. 876.*

² Dr. Fred. John Mouat was a member of the Society of Arts from 1858, and belonged to the Committee of the Indian Section. He died in London in January of the present year, at the ripe age of 81. *Journ. Soc. Arts*, 1897, vol. 45, pp. 159, 734.*

³ Minute Book of the Society, November 30, 1843.

⁴ *Mech. Mag.*, 1846, vol. 45, p. 412.*

⁵ *Journ. Ind. Archip.*, 1847, vol. 1, p. 22.*

¹ On p. 23 l.c. occurs the following remark: "It is quite extraordinary how difficult it is to obtain specimens of either the flower or fruit of this tree, and this is probably the reason of its not having been earlier recognised and described by some of the many botanists who have visited these parts." I may add that I have found it equally difficult to obtain such specimens at the present time.—[E.O.]

² *Journ. Soc. Arts*, 1854, vol. 2, suppl. p. iv.*

³ *Journ. Soc. Arts*, 1863, vol. 12, p. 13.*

⁴ *Journ. Soc. Arts*, 1858, vol. 6, p. 334.*

⁵ It is for this reason, as well as for the historical interest attached to the circular, that the 25 questions will be reproduced

It is interesting to learn that already at that early period sad experiences must have been had with gutta percha, since almost half the number of questions referred to the decay of this substance and its probable causes.

The committee was adjourned on January 16, 1860, on account of a Government Commission being appointed to investigate the subject of insulators for telegraph cables.¹

The Society's *Journal* contains numerous articles and notes referring to gutta percha and its substitutes from the commencement in 1852 up to the present time, some of them being contributed by such authorities as Prof. Bleekrode, Mr. Murton, Mr. James Collins, Mr. John R. Jackson, and others.

Out of these forty references, nearly half appertain to substitutes, mostly to Balata, and one-fifth to the botanical origin of gutta percha, the remainder to application, import, decay, &c.²

I must, however, bring this part of my subject to a close, although it is by no means exhausted, and I will now say a few words about the general properties of gutta percha in the state in which it is obtained from the native collectors; it should, however, be understood that my present remarks refer only to materials of the best description now obtainable in commerce, which are practically identical with those produced on the first introduction of gutta percha 50 years ago.

GENERAL PROPERTIES AND DISTINCTION FROM CAOUTCHOUC.

By far the most conspicuous property of gutta percha and the one which at once distinguishes it from caoutchouc, with which it is so commonly confounded, is undoubtedly that already mentioned by Tradescant, and again insisted upon by D'Almeida as well as Montgomerie, viz., its becoming soft and plastic on immersion in hot water, retaining any shape then given to it on cooling, whereupon it becomes hard, but not brittle like other gums.

in an *Appendix*. That these questions were carefully considered can be seen from the entries in the "Minutes of Committee" Book. In March, 1859, the Committee state that several communications had been received, in reply to their circular, from Malacca, Jamaica, and other places, and specimens of a gum resembling gutta percha had been submitted by the Secretary of State for India for examination and report.—*Journ. Soc. Arts*, 1859, vol. 7, pp. 223,* 556.*

¹ *Vide* the very valuable Report of this Committee published in 1867.

² Appendix III. will contain a summary of all the references to gutta percha I could find in the Society's *Journal* for the convenience of those who wish to consult them.

Caoutchouc, on the other hand, does not soften in hot water, and retains its original elasticity and strength almost unimpaired.¹ However, I wish you to understand that the water, as such, exercises no softening action on the material, the effect being purely one of temperature, which may equally well be produced by hot air, only somewhat more slowly.

The exact temperature at which gutta percha softens depends upon the quality of the material, but even the hardest kinds become plastic above 150° F. (65½° C.)

When gutta percha is heated in air considerably above the boiling point of water, it decomposes and finally ignites, burning with a luminous smoky flame and emitting a characteristic pungent odour resembling that of burning caoutchouc. If the heating takes place in the absence of air—in a retort for instance—gaseous and liquid products are obtained similar to those resulting from the destructive distillation of caoutchouc,² which were examined as long ago as 1835 by Professor Himly,³ brother-in-law of Sir William Siemens.

The oily liquid which distils over consists chiefly of hydrocarbons of the terpene series, which form an excellent solvent for caoutchouc. The two most important components are *isoprene* (C₅H₈) having a specific gravity of 0.682 and a boiling point of 37° C., and *caoutchine*⁴ (C₁₀H₁₆) specific gravity 0.842 and boiling point 171° C. The identity of *isoprene* and *caoutchine* from gutta percha, with that from caoutchouc, was proved by Mr. Greville Williams⁵ in 1860.

Isoprene is a very remarkable compound. Dr. Tilden succeeded in reconvertng it into caoutchouc by treatment with concentrated hydrochloric acid, and later on observed that this polymerisation could also take place spontaneously in the presence of acetic or

¹ Experiments were here made with raw Pahang gutta percha and Para caoutchouc placed in boiling water, to show the difference between the two, the former being soft so that it could be pressed into a mould, whereas the latter retained its elasticity.

² J. G. Scott. *Jour. Agric. and Hort. Soc. of Ind.*, 1844, vol. 3, p. 147.*

³ F. C. Himly. "De Caoutchouc ejusque destillationis siccæ productis et ex his de cautchino novo corpore ex hydrogenio et carbonis composito." Gottingue, 1835.*

⁴ J. W. Bühl. "Untersuchungen über die Terpene u. ihre Abkömmlinge." (Caoutchine can be obtained from Isoprene by polymerisation.) *Chemische Berichte*, 1888, vol. 21, p. 152.*

⁵ C. Greville Williams. "On Isoprene and Caoutchine," *Proc. Roy. Soc.*, 1860, vol. 10, p. 516.*

formic acid.¹ We, therefore, have a product here which, since it can also be obtained from other sources, may on some future occasion form the stepping-stone in the synthetical production of caoutchouc and gutta from the lower terpenes. Quite recently two Russian chemists² cleared up the constitution of isoprene, and found that four of the five carbon atoms are doubly linked together,³ and that it is asymmetric methyldivinyl having the formula : $\text{CH}_2 = \text{C} (\text{CH}_3) - \text{CH} = \text{CH}_2$.

We will now consider the behaviour of gutta percha towards acids and various other menstrua. On the table before me, I have a number of glass jars, containing one-inch cubes of raw gutta percha of good quality, which have been immersed in various liquids few days ago. It will be observed that the weak mineral acids, nitric, sulphuric, and hydrochloric (1 part acid and 20 parts water) have had no action whatever, whereas concentrated nitric and sulphuric acids have strongly attacked the material, the former completely oxidising, and the latter charring it; on the other hand, strong hydrochloric and acetic acids and strong alkalies, such as liquid ammonia, sp. gr. .880, and caustic potash, sp. gr. 1.28, show no appreciable action. It will further be noticed that ether, alcohol, acetone, petroleum-spirit, turpentine and benzole, have had a more or less solvent action on the gutta percha, extracting chiefly resinous substances, whereas carbon disulphide, chloroform, and carbon tetrachloride have completely dissolved it, leaving only the woody and mineral impurities, which partly float and partly sink to the bottom of the jars.

BOTANICAL DERIVATION.

Let me now say a few words on the botanical derivation of gutta percha. In his first communication to the Bengal Medical Board in March, 1843, Dr. Montgomerie states that the specimens, which he submitted with his letter, were the product of a large forest tree indigenous to Singapore, but being prevented from proceeding to the spot, he himself did not see that tree. He offered a reward for specimens of the flower and fruit, but it appears, did not succeed in obtaining any at the

time. In 1844 an amateur collector, the Rev. Edward White, Chaplain of Singapore, sent a dried branch of the tree to the eminent botanist, Dr. William Griffith,¹ of the Madras Medical Service, whose short but brilliant career was so soon after abruptly closed.²

From the small branch, Dr. Griffith was enabled to classify the plant as belonging to the natural family of *Sapotaceæ*³ or *Sapotaceæ*, as it is now commonly termed, and he believed it to be related to *chrysophyllum*, but was unable to decide this point in the absence of either flowers or fruit.⁵ In the following year, Mr. White himself gave a description of the gutta percha plant, and sent it to Dr. Griffith; however, it reached Malacca on the very day of his death, and was subsequently published by Dr. Mouat.⁶ Mr. White here also related the plant to the *Sapotaceæ* and *Ebenaceæ*. His description of the foliage and flowers is excellent, but he did not attempt to give the plant a name, nor did he venture to decide to which of the known genera it bore the greatest affinity.

The gutta percha plant having thus early been allotted to the *Sapotaceæ*—a place, I may at once state, it has retained ever since—I should like to say a few words about the

¹ *Calcutta Journal of Natural History*. Botany, 1845, vol. 7, vol. 5, p. 116.*

² William Griffith, F.L.S., was Superintendent of the Botanical Garden and Professor at the Medical College of Calcutta. He was born at Ham Common, Surrey, in March, 1810, and died at Malacca, February 9th, 1845. (A photograph, taken from a Daguerrottype in the Kew Museum, was shown on the screen.) Griffith was an intimate friend of Dr. Theodore Edward Cantor, of the Bengal Medical Service, whose noble bequest in 1859 enables this Society to provide the annual courses of lectures bearing his name. He described his botanical collection brought from the East, in vol. 21 of the *Asiatic Researches*. It is somewhat remarkable that nearly all the gentlemen connected with the early history of gutta percha, Drs. Montgomerie, Mouat, Oxley, and Griffith, belonged to the Indian Medical Service, as did also Dr. Cantor, and it occurred to me that the recognition by the Society of Arts of Dr. Montgomerie's services for the rediscovery of gutta percha, may possibly have attracted Dr. Cantor's attention to our Society and thus have been the cause of his legacy. The chairman of the meeting on November 21st, 1860, Sir Thomas Phillips, in announcing the Cantor bequest to the members, expressed himself as follows :—" Apart from the substantial advantage to the Society of so considerable a bequest from one who does not appear ever to have been a member, it is very gratifying to the Council to be assured that even in distant lands the proceedings of the Society awaken the interest and enlist the sympathies of their countrymen." (*Journ. Soc. of Arts*, 1860, vol. 9, p. 5.*) [P.S.—I hear from Miss Montgomerie to-day (Nov. 29th) that Dr. Cantor was her father's assistant surgeon some time between 1816 and 1819, which appears to support my contention.—E.O.]

³ R. Brown. "Prodr.," 528 (1810).

⁴ "Endl. Prodr. Norf.," 48 (1833).

⁵ *Journ. Agric. and Hort. Soc. India*, 1844, vol. 3, p. 146.*

⁶ *Journ. Agric. and Hort. Soc. India*, 1845, vol. 4, p. 59.*

¹ W. A. Tilden. "Hydrocarbons of the formula ($\text{C}_5 \text{H}_8$)_n" *Chem. News*, 1882, vol. 46, p. 120,* and 1892, vol. 65, p. 265. Vide also G. Bonchardat, *Comptes Rendus*, vol. 80, p. 1446, vol. 89, p. 1117.

² Wl. Jpatiew and N. Wittorf, "Zur Constitution von Isopren," *Journ. Prakt. Chem.*, 1897, vol. 55, pp. 1 and 4.*

³ This was already stated by Dr. J. H. Gladstone as a consequence of the optical behaviour. *Journ. Chem. Soc.*, 1886, vol. 49, p. 635.*

general characteristics of this particular family of plants.¹

All *Sapotads* are either trees or shrubs, and nearly all natives of the tropics of India, Africa, or America; a few, however, are found in the southern parts of North America and at the Cape of Good Hope. They are characterised by the secretion of milky juices, apparently a waste product, which may possibly serve to heal any wounds made in the plant, either by sealing them up or else antiseptically protecting them, but their true functional importance is not yet fully understood.

This milky juice or *latex* is contained in single cells or sacs—arranged in longitudinal rows like the tannin sacs of the hop and the mucilage sacs of the *Tradescantia*,—which are located chiefly in the inner parts of the bark, but also occur in the pith and the loose tissues of the leaf (in the *merenchyma*), but not in the wood.

The *Sapotads* have round branches, and their leaves are alternate, simple, entire, and petiolate; they are destitute of stipules. The foliage of some of them is remarkable for its beauty, the leaves being of a bright emerald green colour on the upper side and possessing a brilliant metallic lustre like gold or copper on the under surface due to the presence of a silky or downy pubescence. The inflorescence is axillary, and the hermaphrodite flowers are regular and united. The calyx is free and persistent, divided into four to eight segments or petals, which are sometimes disposed in a double series; the corolla is monopetalous, and has the same number of segments, or sepals, as the calyx, the fertile stamens arising from the corolla, are equal in number and opposite to the sepals, the anthers being usually turned outwards, there is one style with an undivided and usually lobed stigma. The fruit is a fleshy berry, containing several one-seeded cells; in some of the species it is considered edible, for instance, that of *Achras Sapota*, known as the Sapodilla plum, or Naseberry, of *Chrysophyllum Cainito*, called Star-apple, and of *Lucuma mammosa*, called Marmalade plum. The seeds are nut-like and coherent,

frequently containing a concrete oil, which is used by the natives for cooking purposes in place of butter, the so-called Galam butter, for instance, being derived from *Bassia butyracea*.¹

The *Sapotaceæ* are closely allied to two other natural families, likewise yielding important economic products, viz., the *Ebenaceæ*, to which the tree producing ebony wood belongs (*Diospyrosebenum*) and the *Styraceæ*, some of which yield useful gum-resins, for instance gum-benzoin (*Styrax benzoin*). The three families form together one natural order, to which the name of *Ebenales* (*Dyospyrinæ*) has been given. It is, perhaps, useful to state, that, botanically speaking, there is no direct relationship between the *Sapotaceæ* and the different families to which the caoutchouc plants belong, although the latter likewise produce milky juices in abundance, whereas neither the *Ebenads* nor the *Storaxworts*, so closely related to the *Sapotads*, contain any latex at all.

The affinities of the three families and the number of genera and species of each, according to Durand's *Index Generum Plantarum* of 1888, are shown in the following diagram:—

GAMOPETALÆ.

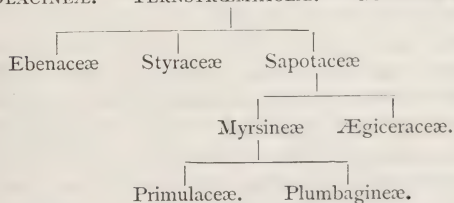
HETEROMERÆ.

EBENALES.

Sapotaceæ (Sapotads)	Ebenaceæ (Ebenads)	Styraceæ (Storaxworts)
40 genera	6 genera	7 genera
400 species.	250 species.	235 species.

Mr. M. Hartog,² from the anatomical study of the development of the flower, expresses his ideas as regards the relations of *Sapotaceæ* to the allied orders as follows, viz.:—

OLACINÆ. TERNSTRÆMIACÆ. GUTTIFERÆ.



But even this more extended relationship does not include any caoutchouc-yielding plants.

¹ I cannot here attempt to give a complete botanical description of the *Sapotaceæ*, but must be content to enumerate some of the points which are of more particular interest in connection with our subject. Those who wish to study this family of plants more closely, I would refer to the older botanical works, such as Burnett's "Outlines of Botany," Lindley's "Natural System of Botany," and his "Vegetable Kingdom," rather than to the more modern text books.

¹ Specimens of these fruits were exhibited, also seeds, and the concrete oil obtained from them.

² *Journ. of Bot.* (new series), 1878, vol. 7, p. 65.*

However, I must not digress any further into these purely botanical regions and will now return to our own subject.

In 1846, Mr. Thomas Lobb, who was on a botanical mission in the Malayan Archipelago for Mr. Veitch of Exeter, sent several well-dried branches of the gutta percha plant from Singapore to Kew Gardens. Unfortunately, they were without corollas, and Sir Wm. Hooker was unable to decide definitely whether the plant belonged to the genus *Bassia*, to which it seemed to have such close affinity. On looking up these specimens in the Herbarium at Kew a short time ago, Mr. Hemsley and I noticed on one of them (No. 290) a curious-looking object, which at once reminded me of a passage in Sir Wm. Hooker's paper of January, 1847,¹ which had always puzzled me and which runs as follows:—

“Mr. Lobb judiciously sent small sections of the wood, which is peculiarly soft, fibrous and spongy, pale-coloured and traversed by longitudinal receptacles or reservoirs filled with the gum, forming ebony-black lines.”

This description was in direct opposition to all I had otherwise read on the subject or seen myself, the wood of the gutta percha tree being neither particularly soft nor spongy or pale-coloured, and the gum would certainly not form ebony-black lines in the wood, even if it should be visible there, which, however, as I have already pointed out, is not likely as it is contained in the inner bark and the pith, but not in the wood. We therefore examined the dubious specimen more closely and found it to be a piece of gutta percha, cut either from a whip or walking-stick ornamented with black stripes, such as the Malays used to make in the early days, and a specimen of which I have before me. Mr. Hemsley placed a small fragment in boiling water, when it softened like gutta percha; and I took another little chip with me and tested its solubility with the same result.² That a man like Hooker should have been misled in this way is very remarkable, and I only mention it here to show that the description of the specimen in the Tradescants Museum as “Mazer wood” is no argument against the assumption that it really may have consisted of gutta percha. I have brought a few specimens of gutta percha with me to-

night, which show each close resemblance to certain kinds of wood.

Here also is Lobb's original specimen and you can judge for yourselves.

The botanical material supplied by Lobb being insufficient, Sir Wm. Hooker wrote to Dr. Oxley for some flowering branches of the plant, and shortly afterwards received from him a twig with flowers and young fruit, contained in a tin box with top and bottom made of the gum itself. One of these covers is still in existence and is exhibited to-night. We shall recur to it later on.

FIG. 1.



Oxley's specimens at last enabled Sir William to describe the plant adequately, and to give it a “station and a name,” as he himself expresses it. They also enabled him to have a drawing made of it by W. H. Fitch, which is reproduced on the diagram Fig. 1 in all its pristine simplicity, and I think beauty. Hooker referred the plant to Dr. Wight's new genus of *Sapotaceæ* and gave it the name of *Isonandra gutta*.¹ Oxley's valuable specimen was appropriately placed in an ornamental

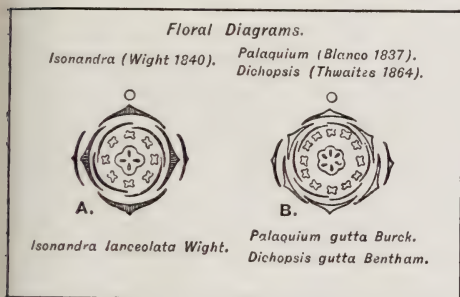
¹ *Lond. Journ. of Bot.*, 1847, vol. 6, p. 33.*

² The result of our tests was corroborated by a pencil note evidently in Mr. Lobb's handwriting, which I detected on my next visit to Kew; it stated that “from the juice of this tree the enclosed whip is made.” This specimen also had a piece of the light-coloured material affixed to it like No. 290.

¹ *Lond. Journ. Bot.*, 1847, vol. 6, p. 463.* In the index of this volume the name is erroneously entered as *Isonandra percha*, a name which has unwarrantably been adopted by several, principally French, writers.

frame made of gutta percha for exhibition in the museum at Kew,¹ where it could be seen till May, 1885, when it was transferred to the Herbarium. It thus happened that Prof. Pierre, the great authority on gutta percha plants, on his visit so Kew missed seeing the specimen, judging from his remarks before the Société Linnéenne of Paris on June 3, 1885, when he said: "Je n'ai pu voir à Kew les échantillons pourvus de corolle envoyés par Oxley à W. Hooker et dont il est question dans le *London Journal* (vi. 463)."² This specimen I am also able to show you to-night. I was sorry to observe that it had greatly suffered from the long exposure in the Museum; the little flowers are discoloured and so much shrivelled up that they are scarcely discernible, even from a short distance; but if you will kindly look at the wall diagram (Fig. 1), you will see how the flower is constructed, and observe that both calyx and corolla are each divided into six segments. However, on referring to Wight's description

FIG. 2.



of the genus *Isonandra* we find that the flowers are stated to be four-parted, so there is a discrepancy somewhere. This was already noticed by Hooker himself, but apparently he did not consider the difference sufficiently important to justify him in establishing a new genus for that purpose, and he evidently knew of no other existing one which would have answered better. Nevertheless, the name originally given to the gutta percha plant by Hooker has now been abandoned for that very reason, and that of *Dichopsis gutta* Benth. et Hook. fil., substituted in its stead in England, and of *Palaquium gutta* Burck, on the Continent.³ The structural difference in the

flower of the genus *Isonandra* on the one hand, and that of the genus *Dichopsis* or *Palaquium* on the other, is shown by the floral diagram (Fig. 2), which represent ideal sections through the four-parted (tetramerous) flower of the one, A,¹ and the six-parted (hexamerous) flower of the other, B, and I need hardly do more than call your attention to it, but I ought not to omit to mention that besides the difference in the structure of the flower, there exists also another distinction of equal importance, viz., the respective presence or absence of albuminous matter in the seeds. I have gone somewhat fully into this matter, because I wish it to be clearly understood that *Isonandra gutta*, *Dichopsis gutta* and *Palaquium gutta*, are only different names for one and the same plant, and that this change of name does not in itself signify, as some people seem to think, that the kind of plant formerly existing is now extinct, and has been replaced by another species.

But allow me to complete the description of the gutta percha plant, which is called by the natives *Taban merah* in Perak and *Niato balam tembaga* (or *abang*) in Sumatra.² It is a lofty tree, with a perfectly straight cylindrical trunk, and has, when fully grown, a height of from 60 to 80 feet, and a diameter of 2 to 3 feet, but it appears that in some localities, Perak for instance, trees considerably over 150 feet high, and 4 to 5 feet diameter, have been met with.³

According to M. Sérullas,⁴ the tree attains maturity at 30 years, and then measures about 45 feet from the ground to the lowermost branches, the circumference being 3 feet at about the height of a man. It is somewhat remarkable that no illustration of the entire tree, appears to have been published anywhere, and I have therefore asked some friends at Singapore to have one photographed for me, if possible, in the jungle, or failing that, in one of the botanical gardens, either at Singapore or Buitenzorg. This has been done, and I

ed. ii., 1845, p. 282), the latter therefore already existed at the time when Hooker published his description. It is for this reason that the Continental botanists adopted the name of *Palaquium* in preference to that of *Dichopsis*.

¹ In Engler and Prantl's "Pflanzenfamilien," Leipzig, 1891, part iv., sec. 1, p. 127 (fig. H), this diagram is erroneously described as that of *Palaquium gutta*, Burck.

² James Collins. *Journ. Soc. of Arts*, 1835, vol. 33, p. 784.* According to Burck, these vernacular names refer to the slightly different variety, *Palaq. oblongifolium* (*Annal. du Jardin Botanique de Buitenzorg*, 1886, vol. 5, p. 74).*

³ L. Wray. jun., *Journ. Straits Branch of Roy. Asiatic Soc.*, 1881, No. 12, p. 210.* Also *Journ. Soc. Arts*, 1883, vol. 33, p. 177.*

⁴ *Comptes Rendus*, 1890, vol. 111, p. 423.*

¹ Vide the Official Guide to the Museums of Economic Botany, Royal Gardens, Kew, 1883, No. 1, p. 91, case 63.*

² *Bulletin mensuel de la Société Linnéenne de Paris*, 1885. No. 63, p. 498.*

³ The genus *Dichopsis* was established by Thwaites in 1864 (*Enum. Pl. Zeyl.*, 1864, p. 176), and that of *Palaquium* by Blanco in 1837 (*Flora Filip.*, ed. i., 1837, p. 403, and

will now show you the photograph of the Taban merah growing in the botanical gardens at Singapore (Fig. 3) on the screen, reserving others till later on. The picture gives you some idea of the general habitus of gutta percha trees, but I must tell you that this particular specimen is not in a very vigorous condition, as it is too much exposed to the sun and has perhaps, too little moisture to draw upon.

The leaves are crowded together at the ends of the branches and are placed alternately; their form is obovate-lanceolate, and they have a small projection or beak at the apex. Leaves from old trees measure about 4 to 5 inches in length and $1\frac{3}{4}$ to $2\frac{1}{2}$ inches in width at the middle, whereas those from young trees are much larger, reaching a length of 9 inches and a breadth of nearly 3 inches. I purposely mention this in order to show that variations in the size and shape of the leaves are not alone sufficient to indicate a difference of species, as has sometimes been supposed. The upper surface of the leaves is bright green and the underside golden brown, when the trees are young, and reddish brown when old, this colour being due to the presence of a dense layer of silky hairs, which also cover the mid-rib and the petiole; the latter is usually about 1 inch or a little more in length. The secondary veins branch out laterally from the mid-rib, nearly at right angles, and are not very conspicuous, being sunk in the substance of the leaf. They number 20 or 30 on each side, which is of some importance to know, as we shall see in the next lecture. The flowers, of which there are four, grouped together in the axil of the leaves, are white, the calyx being of a golden brown colour; there are 12 stamens in single series, inserted into the throat of the corolla with sagittate anthers, turned outwards. The ovary is superior and six-celled, terminating in a single style, which is much longer than the stamens. The fruit is a fleshy egg-shaped berry about $1\frac{1}{2}$ inches long and 1 inch in diameter. (*Vide* Fig. 1, p. 104, and Fig. 4, p. 109.)

I have here some exceptionally fine specimens of leaves, and a twig from the tree in the botanical gardens at Singapore, of which you have just seen the photograph. I have also some branches with flowers and young as well as ripe fruits, preserved in alcohol and formaldehyde. Specimens of the flower and fruit were, as you have heard, already scarce 50 years ago, when gutta percha trees were plentiful; but are still more so now, when the trees are less

frequently met with. I have, therefore, every reason to thank Prof. Sérullas and my Singapore friends for the beautiful specimens which I am able to show you this evening.

I have hitherto spoken of the gutta percha tree as if there was only one kind supplying this valuable commodity, and I have done so purposely so as not to confuse matters, but it is now necessary to be a little more precise and to tell you that although the gutta percha supplied during the first few years may actually have been derived from the one tree only, which I described, yet the commercial sorts of the present day are known to be the products of quite a number of different trees of very unequal value.

I could not possibly attempt to describe all these to you to-night, even if they were perfectly well-known, which, however, is far from being the case; but I must mention at least two more, which are of particular interest, the first being the *Dichopsis oblongifolia* or *Palaquium oblongifolium*, Burck, the Taban sutra of Perak,¹ and the second, the *Payena seerii*, Benth. et Hook. (*Keratophorus Leerii*, Hasskarl), or *Sundek* of Perak, *Niato balam baringin* (or *soendi*) of Sumatra.

The former is very closely allied to the Taban merah (*Palaq. gutta*, Fig. 4), which has been described, and, in fact, its discoverer, the Dutch botanist, De Vriese,² considered it merely a variety of Hooker's *Isonandra gutta*; however, it is now understood to be an independent species.

It is a tree of smaller size, with leaves of a more decidedly yellowish shade of brown on their under surface. The flowers have a reddish tinge, and the general appearance of the bark is said to be quite different.³

The *Payena* on the other hand, although likewise belonging to the *Sapotaceæ*, differs much more from the *Isonandra*. The small leaves are differently shaped, and have a reddish tint when young; the flowers are white, and the fruit, which is fleshy and provided with a kind of horn, has a sweet taste, and is eaten by the natives. A branch with flowers and fruit of each of these varieties are illustrated on the diagrams (Figs. 5 and 6), and some small coloured pictures, besides dried specimens of them, are exhibited on the table. The gums from the two species of *Palaquium* are known under the name of

¹ L. Wray. l.c. p. 212.*

² W. H. De Vriese. "De Handel in Getah-Pertja Leyden, 1856, p. 33.*

³ L. Wray. l.c. p. 212.*

FIG. 3.



GUTTA PERCHA TREE AT SINGAPORE.

getah taban merah and *getah taban sutra* amongst the Malays, and that from the Payena

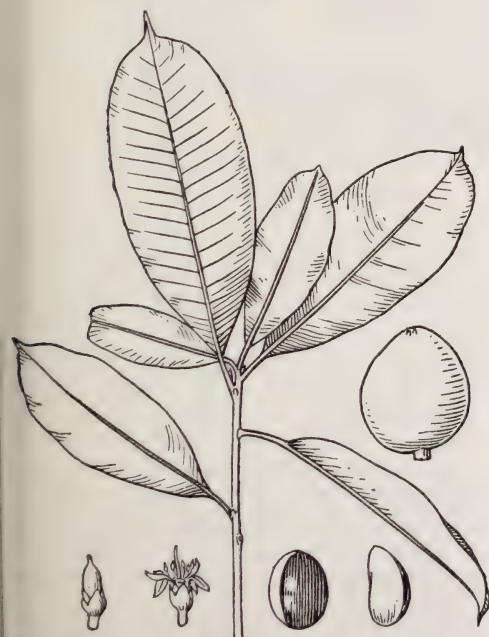
FIG. 4.



PALAQUIUM GUTTA.

as *getah sundek*, or *sooni*, or *soondie*, the latter being the correct Anglo-Malayan expression.

FIG. 5.



PALAQUIUM OBLONGIFOLIUM

The Malay word *getah* which has been rendered into *gutta* simply means the viscous exudation of a plant, and *getah taban* the secretion of that particular kind of tree called *Taban*. As it is from this tree and not from the *pertja* that the gum now called "*gutta percha*" is derived, it is to be regretted that the wrong name was given to it on its first

FIG. 6.



PAVINA LEERII.

introduction into Europe, but in several of the pioneer patents the correct name, *getah taban* or *tuban* was used. The English pronunciation of the words *gutta percha* is the nearest to that of the original Malayan expressions *getah pertja*, whereas in France and Germany they are less correctly pronounced.

GEOGRAPHICAL DISTRIBUTION.

I now pass on to the geographical distribution of the gutta percha plants. At the time when Montgomerie obtained his first specimens, gutta percha trees were plentiful in the ancient forests on the island of Singapore, extending pretty close to the town, and the dried specimens sent to Kew by Dr. Oxley came from the jungle of Bukit Timah only about seven miles from it. Amongst the specimens kindly presented to me by Prof. Sérullas and which I have shown you, there are several collected by him at this locality in 1887 and 1893, viz., the large fruiting branch and these

precious little flowers, as well as some herbarium specimens in this frame. One of these and the little piece of coagulated latex which I hold in my hand have even been collected from a descendant of the very same tree from which the historical branch was taken by Oxley, and which had been pointed out to Sérullas by Don José D'Almeida the younger, who had accompanied Oxley to Bukit Timah in 1847.

I hear from a gentleman at Singapore, who recently visited Bukit Timah (Sept. 19, 1897) in order to take photographs of the gutta-trees there for this lecture, that he saw nine wild *Isonandras* (which are doing well, although left pretty much to themselves), and that there may be a few more hidden in the jungle. Mr. Ridley, the director of the botanical gardens at Singapore, was good enough to accompany him, and consequently there can be no doubt about the identity of the trees. Mr. Ridley, however, is of opinion that they have grown from seeds and not from shoots as M. Sérullas thinks. Some years ago, when the former gentleman was in England, he told me that he knew of the existence of the *Isonandra* trees at Bukit Timah, and in fact, had kept them under observation long before Sérullas discovered them, as he thought, in 1887.¹

I shall now show you the photograph² of these trees on the screen, but I am sorry to say it is not a very successful one, on account of insufficient light in the jungle.

Before 1857 all large gutta trees on Singapore had been cut down by the Malays, and at the present time there are only a few more on the island besides those on Bukit Timah,³ which have since grown up, viz., one in Pasir Panjang, one in the botanical gardens, and a few in a plantation in the north. The tree in the botanical garden was originally described as *Isonandra taban merah*, but it is now labelled *Dichopsis oblongifolia*, Borneo, Malaysia.⁴ It stands in the middle of a lawn in front of the director's house.

As soon as the valuable properties of gutta percha had been recognised in Europe and a

demand had been created for the article, the countries all around Singapore were searched with great avidity for Taban trees, and almost a craze for getah-collecting sprang up amongst the indigenous population. The consequence was that an immense number of trees of great size and age, probably hundreds of thousands were ruthlessly destroyed during the first four or five years, and whole forests denuded of them, like those on Singapore. The exploration was conducted with such assiduity that before the year 1848 came to a close, the much coveted Taban tree had already been discovered in Pahang, Johor, Malacca, Selangor, Perak, and Penang on the Malay Peninsula, besides the islands of Rhio, Gallang, and Singga in the Johor Archipelago. It had also been met with in Siak, Kampar, Indragiri, Tongkal, Jambi, and Palembang, on Sumatra, and in Coti, Passir, Pontianak, Sarawak, and Brunei on Borneo.¹ Since that time the tree has been found in the northern and north-eastern parts of Borneo, on the west coast of Sumatra, and in some other districts on the east and west coasts of the Malay Peninsula.

The region from which all genuine gutta percha is derived at the present day is indicated by a rectangular outline on the map which has been specially prepared for these lectures (Fig. 7). You will observe that this boundary extends six degrees on either side of the equator, and from 99° to 119° eastern longitude; it therefore embraces 12 degrees of latitude and 20 degrees of longitude, corresponding to an area of 1,140,000 square miles, but of this only about 40 per cent. is occupied by land, and of that again only a very small portion is locally suitable for the growth of the gutta percha tree.

Nowhere else on the globe, outside this area of the Malay Archipelago, have any genuine gutta percha trees been found, and this is the more remarkable as the *Sapotaceæ* to which they belong are distributed all over the tropics, and are also of great antiquity, having even representatives amongst the fossil plants. It might, perhaps, be asked whether gutta trees have not been found in the islands adjacent to those confined by the boundary line on the map; for instance, in the large group to the north of Borneo, the Phillipines, or the islands Celebes and Java, to mention only the more important ones. The answer is, that hitherto no genuine gutta percha trees have been discovered there. *Getah* trees, in the Malayan

¹ Vide also, James Collins, *Journ. Soc. Arts*, 1885, vol. 33, p. 784.* Mr. Collins here says that he has been fortunate enough to procure a fruiting branch and a little gutta from the same tree from which the specimens had been sent to Sir Wm. J. Hooker.

² Not reproduced in the *Journal*.

³ Vide Mr. Chas. Wilson's letter to Sir Wm. Hooker in *Hooker's Journ. Bot.*, 1857, vol. 9, p. 252.* According to Oxley (l.c. p. 23) the largest trees had already disappeared from the island in 1847.

⁴ Mr. Ridley thinks it belongs to the same species as the trees on the Bukit Timah.

¹ The spelling here adopted is that used in the *Times Atlas*.

sense of the word, exist, no doubt, but none of the right description.¹

This may possibly strike you as very remarkable unless some satisfactory explanation can be brought forward, and I will endeavour to give you one. If you will glance on the map you will observe that the ocean is shown in two different tints, according to the depth of the water. The lighter tint, between the Asiatic continent and the islands of Sumatra, Java, Borneo, and part of the Philippines, indicates a shallow sea, mostly less than 50 fathoms in depth; whereas the darker one, outside this region and surrounding Celebes and the Lesser Sunda Islands, signifies that there the water is very deep, in fact, mostly

islands, shows that Sumatra, Java, Borneo, and the Philippines have been separated from the Asiatic continent in comparatively recent times only, whereas Celebes and the others are what Wallace calls "*ancient continental islands*."

The dotted black lines indicate the probable configuration of the two ancient continents, of which each group of islands originally formed a component, and you observe how close they were to each other at the points where now the two small islands of Bali and Lombok are situated. The consequence is, that the animal and vegetable life of these two islands, although being only about 15 miles apart, differs much more, than for instance, that of Japan and

FIG. 7.



over 1,000 fathoms. From this it follows that a huge submerged bank exists, which connects the aforesaid islands with the Asiatic continent, whereas the Lesser Sunda Islands and Celebes are completely separated therefrom by a great depth of water. Now this, besides other evidence deduced from the geological and zoological study of these

Britain, which are separated from one another by an entire continent.

The undulating dotted line represents, according to Wallace, the line of separation between the Indo-Malayan and the Austro-Malayan region. This line passing between Borneo and Celebes refers the latter and the Lesser Sunda Islands to an entirely different biological region, sharing none of the peculiarities with the Indo-Malayan fauna and flora.

Having thus satisfied ourselves that Celebes and the Lesser Sunda Islands did not, like the others, in comparatively recent times, belong to the Asiatic continent, it remains to be explained why Java and the Philippines should be devoid of gutta percha trees, although admittedly then forming part of it, like

¹ Mr. R. A. Rolfe, of Kew, has kindly sent me a list of all the *Sapotaceae* hitherto found in the Philippine Islands, but it does not include any gutta percha-yielding plants (*vide* also his paper on the flora of these islands (*Journ. Linnean Soc. Botany*, 1884, vol. 21, p. 283). Mr. van Eeden, the director of the Colonial Museum at Haarlem, also sent me a list of the *sapotaceous* plants found in Java and Celebes, but these likewise do not include genuine gutta producers. Some specimens of *Guttifer* from Celebes, which he obligingly sent me, have been analysed, but they cannot be considered as *gutta percha*, although they have been described as such.

Borneo and Sumatra. The explanation is this. After the typical Malayan fauna and flora had been in existence on the Asiatic continent for some time and probably during the late miocene period (*i.e.*, about the time when the so-called "Red Crag" was deposited in Suffolk) first the Phillipine Islands and then Java were detached from it, while Borneo, Sumatra, and the Malay Peninsula remained still connected.

At this time, the *genera* of Sapotads indigenous to that region were not sufficiently differentiated to produce those particular *species*, which supply a latex yielding gutta percha. When at a later period the subsidence proceeded further, so as to cut off any direct communication with the mainland, the gutta percha trees remained imprisoned on the islands, where they now exist. It is quite probable that in addition to the gradual submersion of the intervening portions of the continent, volcanic action may also have assisted in the further disintegration of the land, a belt of volcanic mountains existing all along Sumatra and Java, as shown on the map, and we know from the recent eruption of Krakatoa in the Straits of Sunda what havoc such a catastrophe can play.

Besides the general climatic conditions, such as the variations of temperature, degree of moisture, prevailing wind, &c., the local conditions, *e.g.*, the composition of the soil, elevation above sea-level, distance from the coast, &c., also play an important part in the development of special features of the fauna and flora in a particular locality, and account for the fact that the gutta percha trees are very irregularly distributed over the different islands, and may even be entirely absent from some parts of them.

About six years ago the directors of the German New Guinea Company asked me whether I thought it likely that gutta percha trees would be found in Kaiser-Wilhelmsland, which they considered probable, the northern portion of their territory having the same latitude as the southern part of Borneo and Sumatra (see map), but for the reasons which I have just tried to explain to you, I ventured to predict that genuine gutta trees would probably not be found there. However, in order to test the matter, the directors instructed their botanists to keep a sharp look-out for such trees during their exploring expeditions, and I furnished them with all necessary particulars to facilitate their recognition. Since then I have received, from time to time, specimens of

various kinds of gums which have been collected there, but as yet not one of them bore any resemblance to true gutta percha, although several—for instance, *Getah Susu*, *Marau* and *Natu*, were derived from *sapotaceous* plants and some even from the same genera, *viz.* *Palaquium* and *Payena*. It was, therefore, somewhat premature to describe these trees as *gutta percha trees* in the "Bulletin" of the Royal Botanical Gardens of Berlin.¹

The various gums from New Guinea which have hitherto been submitted to me are on the table. Only one of them contains a small percentage of caoutchouc-like substance or *pseudo-gutta*.

EXPEDITIONS IN SEARCH OF GUTTA TREES

Let me now say a few words about the various expeditions in search of gutta trees. You have heard how eagerly the search for Taban trees had been pursued by the natives, already at the very beginning, and how successful they were in discovering them almost everywhere in the Malayan Archipelago. In Europe naturally only little attention was paid to the matter until rumours spread about, that in consequence of the ruthless destruction of the trees by the Malays it might possibly occur that the further supply of gutta percha would suddenly cease, if measures were not taken to remedy this state of things, either by regulating the collection of the gutta by law, or if that was not possible, by cultivating the gutta percha trees in the same way as is done with the cacao tree, coffee shrub, and others. With this purpose in view the French Minister of Posts and Telegraphs, M. Cochery, in 1888 instructed M. Séligmann-Lui to proceed first to Malaysia to study the gutta percha trees and then to French Cochinchina to search for them there, and if not found indigenous, to investigate if they could not be cultivated in that locality. M. Séligmann accordingly went to Singapore, and from there started on an exploring expedition, first to Penang, then across the Straits of Malacca to Deli on the east coast of Sumatra. From Deli he followed the coast to Assahan, here penetrating into the interior by the River Ajer Siloh, as far as the village Pasir-Manogeh, where he found various kinds of gutta trees, including the *Mayang Derrian* or true Taban. Returning to

¹ *Palaquium Susu*, Engler; *Payena Bawun*, Scheffer; *Payena Mentzelii*, K. Schumann; *Sideroxylon Kaernbachianum* Engler. "Ueber einige Guttapercha-Bäume von Kaiser Wilhelmsland," von A. Engler. *Notizblatt des Botanischen Gartens zu Berlin*, 1895, No. 3, p. 101.*

Assahan, he again followed the coast to Siak, went up the river of that name as far as Pakan Baru, where he came across the Balam sundek, which he had already found lower down the river; but the Taban tree he was in search of was still six days' journey higher up the mountains. He returned to Siak and thence to Singapore. From the latter place he set out for Saigon, to which place he had previously despatched some young gutta plants,¹ proceeding further north through Gambodia and part of Siam.

Although Séligmann does not appear to have been very successful in his mission, and had to inform the minister that gutta percha trees could neither be found in Cochin-China nor Gambodia, and moreover could probably not be cultivated there, yet he was able to collect a good deal of information from the various people with whom he came in contact during his journey in Malaysia, and this he embodied in a valuable report.²

The second expedition was an English one, arising, it appears, from an enquiry addressed to the Government of the Straits Settlements for information respecting the propagation of gutta trees, by the French Consul at Singapore. The British Resident at Perak thereupon instructed the curator of the Museum at Thaiping, Mr. Leonard Wray, jun., to explore the country and report to him on the various trees from which the gutta percha of commerce is obtained. Mr. Wray, who started on his expedition early in 1883, was able to collect a great many specimens of plants producing gutta percha and caoutchouc, and these he sent to the botanical gardens at Calcutta, Ceylon, and Kew for examination and identification; he also presented a set of them to the Society of Telegraph Engineers in London.³ By the kindness of the Kew authorities and of the council of the Institution of Electrical Engineers, I am able to show you to-night a complete series of the specimens collected by Mr. Wray in Perak. You see here the bunches of leaves and fruit, the wood and bark, and last, but not least, the coagulated latex or getah itself, from seven different trees. I shall have something more to say about the getahs later on, but with regard to

the other specimens, I can only invite you to inspect this unique collection after the lecture, and to identify the localities whence they are derived by means of the special map on the wall, showing the State of Perak on a large scale.¹

Unfortunately time does not allow me to give you any details about Mr. Wray's expedition, but I must not omit to state that this gentleman sent a most interesting report² on it to Sir Hugh Low in September, 1883, in which he gives a great deal of information about gutta trees,³ the quantity of gutta percha obtained from them by the Malays, and other useful data. He also comments upon the wasteful manner in which the gum is collected by the natives, and suggests that the bark—which in the dried state contains over 11 per cent of gutta percha, and is now thrown away—should also be utilised for the extraction of the gum.

In the wake of the English explorer followed a Dutch botanist, Dr. W. Burck, the assistant director of the botanical gardens at Buitenzorg on the island of Java, who towards the end of 1883, received instructions from his Government to proceed to Sumatra and study the gutta percha producing trees on the uplands of Padang (Padangsche Bovenlanden) along the west coast. Dr. Burck discerned 14 different species, yielding gutta percha, of which, however, I will only mention two, viz., the *Niato balam tembaga* or *Durian* of Ampaloo (Halaban) which yields an excellent kind of gutta percha, and the *Niato balam baringin* or *sundai*, which produces the *getah soondie*, a second-class material. The former is identical with *Palaquium oblongifolium* and the latter with *Layena Leerii*, which have both been described to you to-night. Dr. Burck's report to the Government is dated January 10, 1884, it has been translated into French and published at Saigon in the journal "Cochinchine Française" in 1885.⁴ It is a very exhaustive and valuable document, containing a vast amount of original information. Some years afterwards it was followed by another very learned publication on the Sapotaceæ of the Dutch Indies and the botanical origin

¹ Not reproduced in the *Journal*.

² *Journ. Straits Branch Roy. Asiat. Soc.*, 1883, No. 12, p. 207.*

³ The Taban merah and Taban sutra, yielding genuine getah pertja and the tree yielding getah soondie, besides other varieties of *Dichopsis* (*Palaquium*) and *Payena*.

⁴ *Cochinchine Française*. "Ex.ursions et Reconnaissances," Saigon, 1885, vol. 9, pp. 153-207.* According to M. Sérullas this translation is not quite trustworthy.

¹ It appears that all the plants sent to Saigon by M. Séligmann-Lui were, somehow or the other, mislaid on their arrival in French Indo-China. (E. Sérullas "Lum. électr.," 1890, vol. 38, p. 407.)*

² *Annales télégraphiques*, 1883, vol. 10, pp. 481,* 573.*

³ *Journ. Soc. Electr. Engin.*, 1886, vol. 15, p. 305,* and 1888, vol. 17, p. 568.*

of gutta percha,¹ which has since become a standard work on the subject. The diagrams exhibited here to-night are copies of the beautiful illustrations accompanying the work. On returning from his expedition Dr. Burck brought a number of young gutta trees with him, which were planted in the botanical gardens at Buitenzorg and subsequently transferred to the Cultuur Tuin at Tjikeumeuh close by. He also sent dried specimens of the plants to the various European Herbaria, and one of them is exhibited here to-night from Kew.

Dr. Burck only heard of M. Séligmann-Lui's expedition after his own return, but they compared notes, and on the whole agreed in their conclusions. He was also at the time ignorant of Mr. Wray's explorations in Perak.

Each of the three expeditions I have hitherto mentioned extended only over the comparatively short period of a few months, but that of M. Sérullas, which now followed, occupied almost five years, viz., from 1884 to 1889.

The plants collected in 1881 by M. Séligmann in Sumatra having failed to reach Saigon, the director of the botanical gardens there applied to the authorities at Buitenzorg for young plants of the *Niato balam tembaga*, discovered by Burck at Ampaloo, but instead of the particular plants asked for, "others of the better variety known as *Hooker's Isonandra* were supplied." This was in 1884, and M. Sérullas, who was then at Saigon, advised the Government not to accept the plants, nor others received from Singapore, as they were not of the right kind. In consequence thereof, the French Colonial Secretary, in concert with the Post and Telegraph Department, commissioned M. Sérullas to proceed to the Malay Peninsula and himself to collect the plants which he considered suitable. At that time Sumatra was reported by the Dutch Government to be unsafe on account of the internecine wars between the various Batak tribes.

During the long preliminary exploration in the Malay Peninsula, M. Sérullas found a great many adult trees of the *Taban merah* and *Taban sutra* in the forests of the savage Sakais, on independent territory, but, being exhausted by fever, he had to return to France almost in a dying condition. Having barely recovered, he returned to the Peninsula, and from there, under great difficulties, brought all the plants he required to Singapore. It was here, after having informed the Government at Cochinchina

of his success in obtaining suitable plants, and whilst he was awaiting their reply, that in April, 1887, he found in the jungles of Bukit Timah the authentic specimens of Hooker's *Isonandra gutta* in blossom, a discovery which he at once communicated to Saigon. The consequence of this was that the Governor now rejected all the plants previously collected by M. Sérullas on the Malay Peninsula,¹ and only consented to accept specimens of the original *Isonandra gutta* of the forests of Singapore. This decision, however, was subsequently withdrawn on the intercession of M. Lannesson, Professor of Botany at the Faculté de Médecine of Paris, who, at the time, happened to be in Malaysia, and the plants were, after all, forwarded to Saigon. There they were transplanted at the beginning of the dry season, in spite of the earnest entreaties of M. Sérullas, and as they were also neglected, they all soon perished.

In December, 1887, M. Sérullas again went to the Malay Peninsula, but instead of young trees he now took the stools of old ones with the shoots attached and transported them to Singapore. Here he carefully nursed them, and within three months had the satisfaction of seeing at least 20 shoots of vigorous growth on each stool. Sérullas received further instructions to collect seeds of the *Isonandra gutta* in the forests of Singapore, but he was refused the assistant for whom he asked, by the Minister, and whilst completing the collection he had a severe attack of dysentery. Again returning to France to recruit his health he had the disappointment of learning there that his mission had been suppressed, and that all the little plants which he had reared at Singapore with such infinite care and trouble had been abandoned by the French Government which, since then, had entirely ceased to interest itself in the matter.² Thus ended the fourth and, up to the present, last Government expedition in search of gutta percha trees,³ and we have now to see what attempts have been made to cultivate them.

(To be continued.)

¹ A collection of dried plants collected on the Peninsula by M. Sérullas, and presented by him to the lecturer, were exhibited.

² Vide M. Sérullas' interesting articles in *La Lum. electr.* 1890, vol. 3⁸, pp. 35*, 406*, 462*, 524*, 570*, 612*. Also his paper in the *Compt. Rend.*, 1890, vol. 111, p. 423*.

³ Mr. H. N. Ridley, of Singapore, made some collecting trips during 1890 to 1893 in Pahang, Kelantan, and Tringganu, and found the *Palaequium gutta* in several places in the Tahan woods; he says it is plentiful there, and a considerable quantity of gutta percha is still collected by the Sakais and sold to the Malays. *Trans. Linnean Soc., Second Series, Botany*, 1893, vol. 8, pp. 271*, and 317*.*

¹ "Sur les Sapotacées des Indes néerlandaises et les origines botaniques de la gutta percha," par W. Burck. *Annales du Jard. Bot. de Buitenzorg*, 1886, vol. 5, pp. 1-85.*

Miscellaneous.

WILD SILK REELING IN CHINA.

The Cheefoo Filanda, as the establishment for reeling wild silk by machinery is known, is an interesting enterprise for several reasons, one being that it is the only flatnre in China in which wild silk is reeled by steam. Her Majesty's Acting Consul at Cheefoo states that this establishment, conducted by a very enterprising Cantonese with Chinese capital, is, as a commercial undertaking, rather in the tentative stage, one difficulty being to maintain a full and regular supply of cocoons, and another to keep up the full strength of the hands employed. The cocoons are procured, not only from the Province of Cheefoo itself, but from the South Manchurian regions, known as Liaotung, of which the little-known town and junk anchorage of Ta Tung Kow is the chief port and outlet. The Filanda, when working full power, can run 580 reels, each employing one coolie, but the average number in work is about 540, and this number includes some 120 apprentices, mostly boys. The hours are about 12 to 13 a day, and it is stated that though the factory rooms are large, airy, and lighted from the north, the coolies are not very healthy nor clean, and they suffer greatly from strain on the eyes. The system of payment is to give each man daily, food worth 60 cash (say 1 $\frac{3}{4}$ d.) plus 19 cash (about $\frac{1}{2}$ d.) per ounce of silk reeled. The pay also varies somewhat according as the thread is wound from 4 cocoons (the best), from 8, or from 16. Broadly speaking, however, the most a skilful and hard-working hand can turn out in a day is 6 ounces, which with his food and small gratuities means that he can earn from 180 to 200 cash a day (5 $\frac{1}{4}$ d. to 5 $\frac{3}{4}$ d.) This is a little more than the rate for local carrying coolies (120 cash, say 3 $\frac{1}{2}$ d.), or for unskilled labour in general, which is 150 cash, or 4 $\frac{1}{2}$ d. The Filanda can produce some 40 piculs or 5,300 lbs. a month of reeled silk. Nothing is wasted. The so-called waste silk, or coarser outer coating of the cocoons, being used for making plush, and the black and unpleasant-looking pupa finding a ready sale as an article of food, though, as the Consul says, in what form and by whom eaten is somewhat of a mystery. The machine-reeled thread is very different in appearance, even to an outsider's eyes, from the thread when reeled in the customary way by hand, which looks coarse, dirty, and irregular by comparison.

Correspondence.

THE PURIFICATION OF SEWAGE BY BACTERIA.

Greatly to my regret, a very severe cold prevented my being present when Dr. Rideal read his interesting paper on the above subject before the Society of Arts, on Wednesday evening last. With much in

the paper I agree, but there are also a number of questionable statements. With these latter I do not wish to deal, especially as some of them have been already dealt with by Mr. Naylor and Mr. Thudichum. There is, however, one paragraph in Dr. Rideal's paper which I cannot pass over in silence: it is the second paragraph on page 84, in which it is stated that "until quite recently it was believed that the purification of sewage was simply a process of oxidation, and that air or oxidising chemicals were the chief factors required." Now I have, since the years 1884 and 1885, by speech and writing, endeavoured to convince chemists and engineers that the essential agents concerned in the destruction of sewage were living organisms. I have proved—as long ago as 1885—that sterile sewage abstracts no oxygen from thoroughly aerated sterile water. My statements were, at first, met with ridicule, but, like all truths, they have gradually made their way, and are now, I believe, universally accepted as facts. I do not wish to trouble your readers with many extracts from papers or speeches of mine, but as I look upon the biological treatment as the greatest advance made in the disposal of sewage during the century, I wish to place my connection with the starting of the method on a clear footing. Three short extracts from an address of mine to Section III. of the Sanitary Congress held at Bolton in 1887, will, I think, be sufficient.*

"Shortly stated it is as follows. If a pure, thoroughly aerated water be kept out of contact with air for say ten days, it will be found to have remained fully aerated. The same will be found to be the case even with an impure water, provided the water contained no living organisms. Sewage polluted water when sterilised by heating remains fully aerated. If, however, the water contains living organisms, the state of aëration will alter, and in the majority of cases will diminish."

"In the first place, I am decidedly of opinion that whatever scheme may be adopted (except destruction of the sewage material by fire), the agents to which the ultimate destruction of sewage is due, are living organisms (not necessarily micro-organisms), either vegetable or animal. If this be so, our treatment should be such as to avoid the killing of these organisms, or even hampering them in their actions, but rather to do everything to favour them in their beneficial work."

"To sum up, let natural agencies have their way, assist and direct them into proper channels as far as you can, but interfere with them as little as possible."

These statements cover the whole ground, and they clearly state the principles on which the biological treatment of sewage is based.

I am perfectly aware, no one more so, that the advancement of an idea is one thing, the successful carrying of the idea into practice, quite another, and all honour is due to those who, like the Massachusetts Board, Mr. Dibdin, Mr. Cameron, and others, have

* "Trans. Sanit. Inst.," vol. ix. pp. 365, 367, 393.

by their labours accomplished this. The fact remains that, without the prior existence of the idea, such work would have been impossible.

The mention of the Massachusetts Board reminds me that the highly valuable experiments of that Board were not a continuation of Sir Edward Frankland's experiments on intermittent downward filtration, highly interesting and valuable though they were at the time, but were, unless I am greatly mistaken, the more or less direct outcome of the labours of Mr. Dibdin and myself on the treatment of sewage.

A. DUPRÉ.

December 18th, 1897.

Notes on Books.

THE DWELLING HOUSE. By G. V. Poore, M.D.
London, 1897. Longmans, Green, and Co.

It would seem to be difficult to write anything fresh on domestic hygiene, and yet Dr. Poore has succeeded in doing so. The views expressed show a good deal of divergence from orthodoxy, and differ considerably from the usual sanitary gospel. Dr. Poore is a vigorous opponent of the water-carried system of sewage, though, at all events so far as town houses are concerned, he does not appear to be prepared to suggest anything in its place. For houses in the country his views will recommend themselves to all who can take an unprejudiced view of the subject, and his book is one which can be wisely studied by those who are so situated as to be able to put his suggestions into practice. His principal text is that all excrementitious and other waste matters should be spread on the surface of the soil, or buried very close to the surface. Thus treated they are rapidly reduced to humus and become at once harmless to animal and helpful to vegetable life. Surface wells, receiving the drainage from land thus treated, are, he shows, quite harmless, and form a safe source of water supply, provided of course that no drainage from the surface, or from the upper few feet of soil, can gain access to the well. He describes a well of this sort in a plot of ground of an acre and a half, which receives all the refuse from a house and a number of cottages. The upper part of the well is carefully concreted round, so as to avoid direct contamination, and it supplies water which has successfully withstood chemical and bacteriological tests through a considerable time.

That by diluting our sewage with enormous volumes of water, we are bringing it into precisely that condition in which it is most difficult to treat innocuously and effectively, is probably certain, but this great convenience of using water to promptly wash away and carry off all offensive matters must be taken as counterbalancing its drawbacks. Modern cities, perhaps, can never be sanitated by other means. For isolated dwelling and villages, the dry system has so many advantages, that the more con-

venient water system will probably be replaced by it to a large and larger extent, as true sanitary knowledge increases.

ELECTRIC MOVEMENT IN AIR AND WATER. By Lord Armstrong. London, 1897. Smith, Elder, and Co.

Many years ago—about 1840—Lord Armstrong invented what was at the time the most powerful generator of electricity, the hydro-electric machine, in which electricity was produced by the friction of aqueous particles in a partly condensed jet of steam, as it issued under pressure from a suitably formed orifice. Sparks of 22 inches were given by this apparatus, and many remarkable experiments were made with it, experiments which at that time could not be repeated with any other. Amongst others, one in which a strand of cotton, connecting two vessels of water themselves in connection with the terminus of the machine, is drawn into one vessel, while water is drawn, in the opposite direction, into the other. A consideration of this experiment led Lord Armstrong to certain views as to the nature of electricity, but he abandoned his electrical investigations, and the hydro-electric generator was never applied to any practical purpose. Of late years he has returned to his early work. He found that the experiments which had been successfully made in the open air could not be repeated under cover, and he was therefore led first to use powerful induction coils instead of a steam generator, and afterwards to have recourse to the Wimshurst machine.

Starting with a repetition of his earlier experiment, in which a cotton thread was caused to travel from a vessel of water negatively electrified into another positively electrified, he went on to test the effect of the current upon minute solid particles in its neighbourhood. He began by passing a succession of spark discharges through a hole in a sheet of cardboard covered with a film of light dust. The result was the formation of a large ring, or series of rings, suggestive of the well-known smoke rings and of the vortex action by which they are formed. Similar results were more easily produced with various dusts on a glass plate—rather more elaborate patterns resulting with a powerful Wimshurst machine. In the next series of experiments a photographic plate was substituted for a dust plate, and a Wimshurst discharge taken from a metallic disc resting on the insulated plate, the other pole of the machine being underneath the plate. In this case a very beautiful foliated discharge resulted, extending in all directions from the central metallic disc and forming a luminous star. By varying the conditions other patterns of different complexity and extreme beauty were produced. Many of these have been reproduced with very great care as illustrations for the work under notice. Some of these are of natural size; others are enlarged to illustrate the theory of vortex movement, which Lord Armstrong has formed, and which this book is meant to illustrate.

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FRIDAY, DECEMBER 31, 1897.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.

JUVENILE LECTURES.

The usual short course of lectures adapted for a juvenile audience will be given on Wednesday evenings, January 5 and 12, 1898, by Professor WILLIAM RAMSAY, Ph.D., F.R.S., on "Fire."

A sufficient number of tickets to fill the room have been issued to members, but a few tickets can still be supplied to such members as have not received any, if application is made at once.

COVERS FOR JOURNAL.

For the convenience of Members wishing to bind their volumes of the *Journal*, cloth covers will be supplied post free for 1s. 6d. each, on application to the Secretary.

LIST OF MEMBERS.

The new edition of the List of Members of the Society is now ready, and can be obtained by Members on application to the Secretary.

Proceedings of the Society.

CANTOR LECTURES.

GUTTA PERCHA.

By DR. EUGENE F. A. OBACH,
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Lecture I.—Delivered November 29, 1897.

(Concluded from p. 114.)

EXPERIMENTAL CULTIVATION.

In May, 1847, Messrs. Wilkinson and Jewellery of London, received a consignment of

about two dozen young gutta percha trees from Singapore, which they presented to Kew Gardens, receiving an acknowledgment from Sir Wm. Hooker.¹

I was unable to find out what became of these plants, but on searching the older issues of Hooker's *Popular Guide to the Gardens*, I noticed that in 1849 a living gutta percha plant (*Isonandra gutta*) existed in the low double propagating house, No. 4, and was described as having been presented by Dr. Oxley with other rarities from Singapore. In later editions of the *Guide*, the plant is mentioned in plant-house No. 16, the museum stove, and the miscellaneous tropical house, and it was still in existence there in 1860, but it appears to have been considered merely as a curiosity. On the other hand, serious attempts at cultivation were made on the island of Singapore as early as 1848, when no less than seven plantations of gutta trees were established there by Oxley, Montgomerie, D'Almeida, and others, but one by one they fell into the hands of Chinamen, who, in course of time, replaced the gutta trees by other more remunerative crops. Dr. Oxley's plantation had been stocked with plants from the forest of Bukit Timah, and was therefore supplied with the best kind of tree obtainable, but it seems that some of the other plantations were supplied with a species of *Ficus* by mistake.

Out of the plantation of 4,000 trees, established by Sir José D'Almeida at Serangong, some adult specimens still survived in 1888, but were then just on the verge of extermination,² and now only a few trees exist in the north of the island, and their latex is used by the Chinamen for adulterating opium.³

The Botanical Gardens at Buitenzorg received a number of young *Isonandras* from Singapore in 1847, half of them being still alive two years later. In 1883 two of the remaining trees bore fruit and seeds in abundance, and in February of the following year 150 young plants, reared from these seeds, were planted in the *Cultuur Tuin* of Tjikeumeuh.⁴

In 1856 the Buitenzorg Gardens also received 2,000 young specimens of the Niato balam tembaga from the west coast of Borneo, which the Director, Mr. J. E. Teijsmann, distributed to three different places on the

¹ Vide the pamphlet by Mr. H. W. Jewesbury, *Introduction of Gutta Percha into Europe*, 1883, p. 11.*

² Sérullas, loc. cit., p. 616.*

³ Vide *Straits Times* of June 3rd, 1892.

⁴ *S' Lands Plantentuin te Buitenzorg*, Batavia, 1892, pp. 445* and 488.*

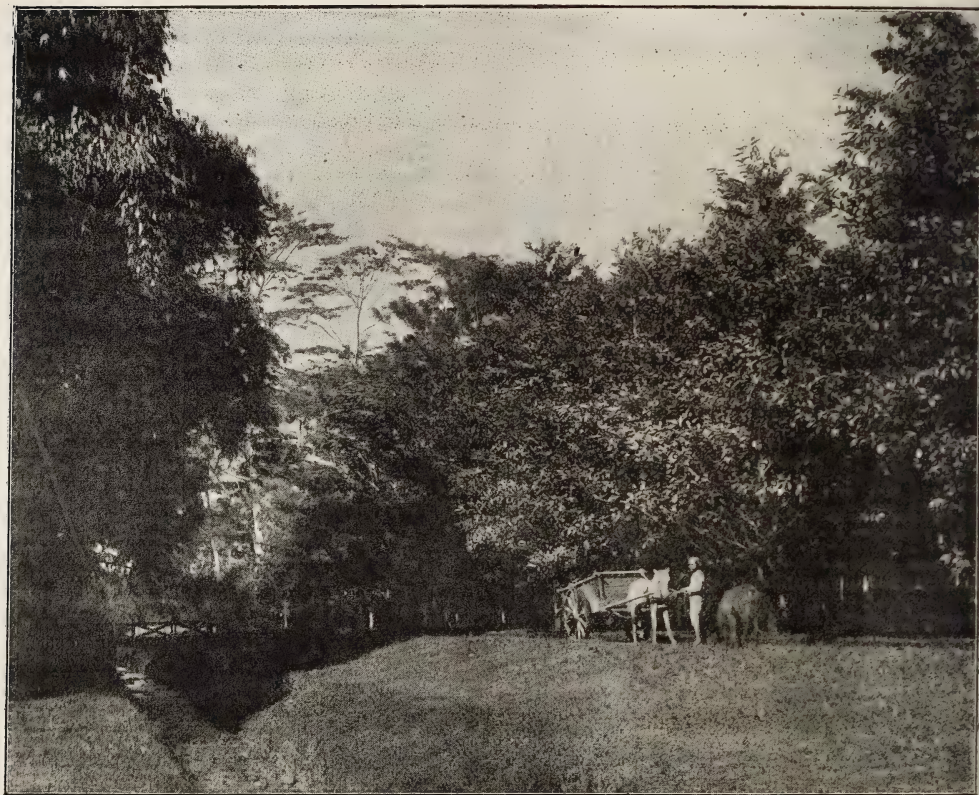
island of Java; from two they disappeared again in the course of time, but, of those which were sent to Purwokarta, nearly 80 reached maturity, and, although perhaps not very vigorous, yet ever since 1883 they have regularly produced seeds which have been found most useful for propagation.¹

In 1884, several kinds of *Palaquium* as well as *Payena* were planted at Tjikeumeuh, and amongst them the *Pal. oblongifolium* brought from Padang by Dr. Burck, the others con-

plan¹ of the Gardens, on which I have marked those sections and added the names of the various kinds of gutta trees which are cultivated there.

In the year 1885, an experimental Garden (*Proef Tuin*) on a larger scale was established by the Dutch Government at Tjipetir, in the Preanger Regency, at an elevation of about 1,300 feet above the sea-level, and extending over 250 acres. Here the same kind of trees as at Tjikeumeuh were planted; and I can show you

FIG. 8.



sisting of *Pal. gutta*, *Pal. Treubii*, *Pal. Borneense*, and *Payena Leerii*. By the kindness of the Director of these Gardens, Dr. Treub, I am able to show you a photograph of the *Palaquium* sections (Fig. 8), and I will also show you on the screen a copy of the

the photographs of two of these plantations taken when the trees were about five years old. The first slide shows the young *Palaquium gutta* trees, planted without shade trees, and the next the *Payena Leerii*, shaded by tall trees (*Albizia moluccana*) planted at the same time.²

¹ According to the last published report of the Buitenzorg Gardens for 1895 seeds and young plants of various gutta trees were distributed during that year. Vide *Verlag van S'Lands Plantentuin te Buitenzorg*, Batavia, 1896, pp. 36,* 156,* 175,* and 180.*

¹ Not reproduced in the *Journal*.

² I have to thank Professor Tschirch, of the University of Berne, for these photographs, which were published in his well known work: *Indische Heil- und Nutzpflanzen*, Berlin, 1892, Tables 126, 127. They are not reproduced in the *Journal*.

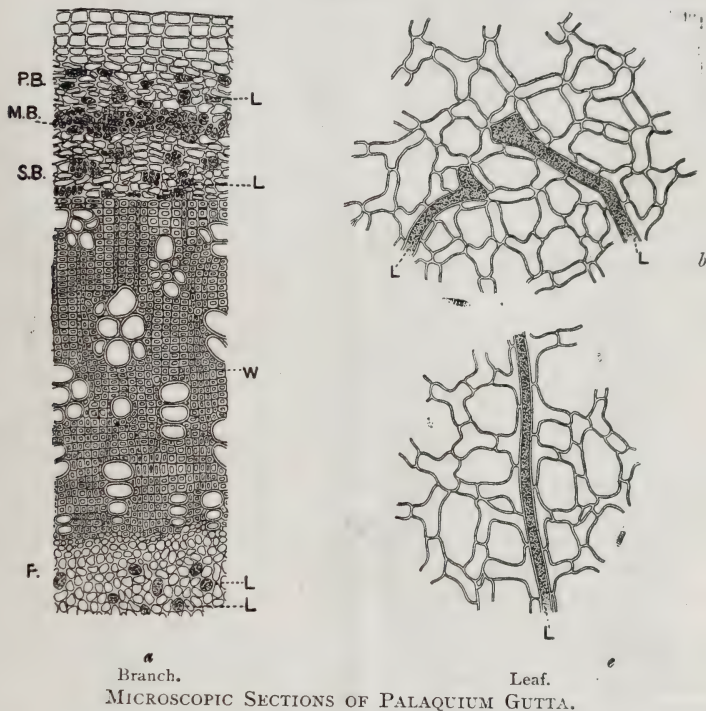
In a letter, recently received from Mr. van Eeden, the Director of the Colonial Museum at Haarlem, he tells me that the *Palaquium* trees at Tjipetir bore abundant fruit in 1895, *i.e.* eleven years after having been planted, and that they are now being cultivated on a still larger scale. I have here specimens of gutta percha obtained at Tjikeumeuh from trees about ten years old tapped for experimental purposes.

Before leaving this subject, I will just mention that some gutta trees were also grown in the Government Gardens at Peradeniya and Henaratgoda in Ceylon from seeds supplied

assure you, on the high authority of Dr. Treub, that this mode of propagation is quite feasible; although the seeds do not keep their germinating power very long, and a more certain method is that technically known as *Marcottage*, which consists in burying a branch of the tree in the ground, allowing it to take root, and afterwards separating it from the parent plant.

According to information obtained for me from a Chinese gutta-planter, cuttings from old trees can also be used for propagation, and it is best to insert them into a cocoanut to

FIG. 9.



Branch. Leaf.
MICROSCOPIC SECTIONS OF PALAQUIM GUTTA.

from Perak by Sir Hugh Low in 1882,¹ and yielding the material known as Getah taban utch (probably *Dichopsis polyantha*, Benth.); there were also some young trees of the kind yielding Getah sundek (*Payena Leerii* Burck) in existence at that time; however, as no mention is made of them in the last report on these gardens,² I cannot say whether they are still there now.

PROPAGATION OF GUTTA TREES.

It has variously been asserted that gutta trees cannot be reared from seeds, but I can

take root there, and then transplant them. Young plants reared in this way, can be bought at Penang and Batavia at 50 cents. apiece. Saplings from the jungle, where obtainable, or from plantations, are also suitable for transplanting, and they can now be bought in Malacca¹ at a very low price. Dr. Treub finds young plants reared from *Marcottes* more vigorous than those from seeds. Grafting is declared to be impossible by Mr. Ridley, on account of the fungi and bacilli which attack the plant. M. Sérullas, as I told you, took the whole stools from the forest and transferred them to a nursery.

¹ Henry Trimen's *Report on the Roy. Bot. Gard. at Ceylon* 1882, p. 13.

² J. C. Willis's *Report for 1896*.

¹ From a plantation recently opened there by a Chinaman.

COLLECTION OF GUTTA PERCHA FROM THE TREE.

I must now tell you how the latex is obtained from the trees. You will remember that it is contained in isolated receptacles or sacs, chiefly in the lower parts of the bark, but also in the leaves. Diagram (Fig. 9, p. 119)¹ shows a section through a small branch, *a*, and a leaf, *b* and *c*, of the *Palaquium gutta*, and you observe the numerous latex receptacles, *L*, in the primary and secondary bark, *P.B.* and *S.B.*, of the branch as well as in the pith, *P*. The sections through the leaves show you, in one case, *b*, the termination of two latex sacs, and in the other, *c*, the course of one of them within the imperfect cellular tissue or *merenchyma*.

In order to get at the latex, it is therefore necessary to cut through the bark and cause it to exude. The practice of the Malay getah-collector is invariably to fell the tree, chop off the branches, and ring the bark at distances of 12 to 18 inches all along the trunk. The milky sap soon fills the grooves cut into the bark, and with the better kinds of trees, quickly coagulates; it is then scraped off with the point of a knife. In the case of inferior trees, the latex requires a much longer time to curdle, and has to be collected in a receptacle of some sort, a cocoanut-shell or the spathe of a palm, for instance, placed under the trunk. The latex is then taken to the huts and gently boiled either by itself or with the addition of water. The material obtained without water is called a *goolie*, the other a *gutta*; but the two kinds are mostly mixed together. The *goolie* is more compact than the *gutta*, and it has a dough-like smell. For felling the trees the Malays use a small axe, called a *billiong*; it has a chisel-like iron blade secured to a wooden handle by a lashing of *rôtan*. The branches are chopped off with the *pârang* or the *gôlok*, and these are also used for ringing the bark and scraping off the getah.

A collection of these native instruments, presented to Kew Gardens by Sir Hugh Low, the Resident of Perak, and Mr. Murton, is exhibited here, and we have photographed them with some specimens of wood from gutta trees found in Perak. They will now be projected on the screen.² (Fig. 10, p. 121.)

¹ Otto Oesterle, *Archiv. der Pharm.*, 1892, vol. 230, Plates I. and II. Unfortunately, some microscopic sections of *Palaq. gutta*, kindly prepared for me by Mr. C. Robertson Glasgow, formerly at Kew, but now at Singapore, did not arrive in time to be shown at the lecture, as intended.—E.O.

² Explanation of Fig 10:—(a) Billiong—(b) Pârang—

I am also able to show you on another slide the way in which the Malays use these tools for extracting the gutta from the trunk in the western parts of Sumatra. The group was arranged by Dr. Burck, who is himself in the picture. (Fig. 11, p. 123.)

Here is a piece of the trunk of a gutta tree of respectable size, and about 60 years old, which was kindly presented to me. It measures over 40 inches in circumference; parts of it have been polished to show the structure of the wood. An expert whom I consulted, expressed the opinion that it was probably not of much use as timber, which is contrary to the opinion expressed in some books.

As regards the quantity of solid gutta percha yielded by an adult tree, the data given are very conflicting. Older writers like Oxley¹ and Logan² give as the average 13½ lbs. and 5½ lbs. for Singapore and Johore respectively, but later observers quote much smaller figures. Wray,³ for instance, obtained only 2 lbs. 5 oz. of fairly clean gutta percha from a Taban merah at least 100 years old, and 2 lbs. 11 oz. from a Taban puteh. Burck obtained on an average only 11 oz. from adult trees in West Sumatra, and Sérullaz 13½ oz. from a giant tree felled in Pahang by Dyaks.⁴ The yield evidently depends greatly upon the kind of tree, manner in which it is felled, the season, &c., the milky sap being said to run most freely directly after the rainy season is over. When the tree is wounded without first being felled, the latex flows much more tardily and sparingly and also coagulates quicker, the output is therefore notably smaller, this being one of the reasons why the Malays still resort to the old method of cutting the trees down before bleeding them. With caoutchouc trees it is different, their latex is much thinner and does not easily coagulate; consequently the tapping of living trees is the usual practice. Trees yielding a special kind of gutta percha (*Balata*) likewise contain a more fluid milk-sap, and here tapping follows the rule, as we shall see in our next lecture.

If we accept Mr. Wray's figure, the average yield of an adult gutta tree of good

(c) Gôlok (H. C. Murton, 1878)—(d) Wood from tree yielding Gêtah tâban puteh (H. C. Murton, 1878)—(e) do., do. (Sir Hugh Low, 1883.)

¹ *Journ. Ind. Archip.*, 1847, vol. i., p. 25.*

² *Journ. Ind. Archip.*, 1847, vol. i., p. 262.*

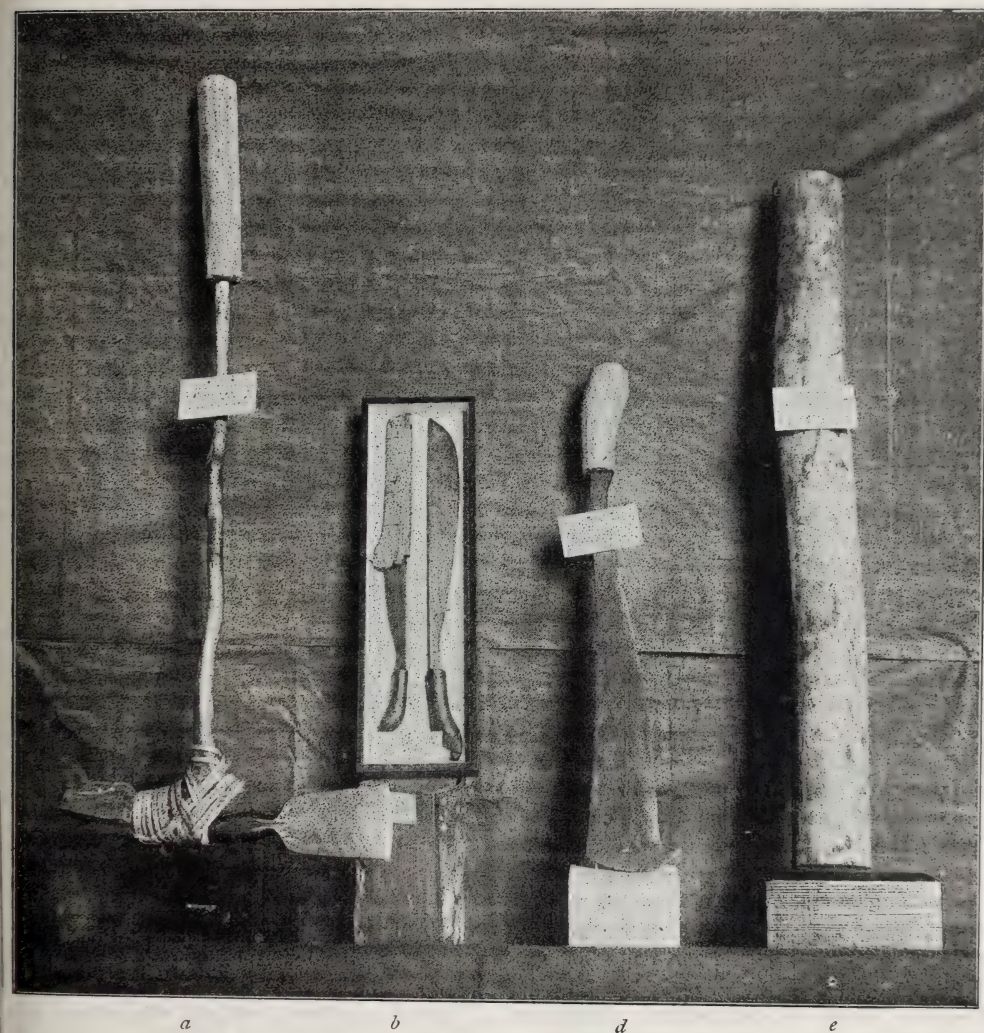
³ *Journ. Straits Branch Asiatic Soc.*, 1884, No. 12 pp. 21 and 214.*

⁴ E. Jungfleisch, *La Production de la Gutta Percha*, Paris, 1892, p. 4.*

quality is about $2\frac{1}{2}$ lbs., which, if anything, is probably too high an estimate. Taking the price of gutta percha at 3s. 6d. per lb., the value of the entire yield of a tree would be only 8s. 9d., and it is, therefore, not very surprising that the Malay collector as well as the Chinese dealer tries every expedient to increase the amount of the produce, the

flat bottles, &c.—which are to a certain extent characteristic of the district whence they come, and I have brought various specimens with me to-night for your inspection. Sometimes the native collector shows artistic proclivities, and moulds the gutta percha into the form of birds, alligators, quadrupeds, &c., specimens of which you see here. They are

FIG. 10.



former by blending it with the juices of other plants, ready at hand in the forest, and the latter by recooking the materials which he receives from the jungle, and mixing them with bark, sawdust, ground sago, &c.

The gutta percha as it finally arrives on the market is usually in the form of large blocks of various shapes—cylindrical rolls, square cakes,

not at all bad productions, although by no means the best I have seen. (Fig. 12, p. 124.)

In the early years the Malays went more seriously to work, and made a number of useful articles, which they brought into town for sale, such as riding-whips, walking-sticks, pails, jugs and basins, and so forth, and Professor Solly mentions in 1845 that a batch of such

sticks had then just been received at Liverpool from Singapore. I also heard from friends that in the early fifties gutta percha riding-whips were not infrequently met with on the Continent. I am able to show you a number of these articles, which were sent to the Great International Exhibition of 1851,¹ and as they will probably not exist for many more years, I had them photographed, and shall show you the result on the screen (Fig. 13). Please observe the black stripes on the riding-whip and walking-stick, as well as on the basin and jug, to which I have alluded before. Also please notice the shallow tray next the jug, which is the gutta percha cover of the tin box in which Oxley sent the flowering branch of the *Isonandra* to Sir Wm. Hooker, in 1847. The specimens of wood also shown on the photograph are from the Taban merah (*Palag. gutta*).

CHEMICAL ANALYSIS OF GUTTA PERCHA.

I will now briefly consider the chemical composition of gutta percha and its analysis.

The very first specimens sent to the Bengal Medical Board by Dr. Montgomerie in March, 1843, were already submitted to chemical tests by Dr. Mouat² and Mr. J. G. Scott.³ They tried its solubility in various menstrua, such as water, alcohol, ether, naphtha, oil of turpentine, &c., and subjected it to destructive distillation. From their experiments they concluded that gutta percha was a "variety of caoutchouc," having certain remarkable properties of its own. Prof. Edward Solly,⁴ who examined the samples sent to the Society of Arts, as well as some specimens from the East India House, received by him through Dr. Royle, read a paper before the Chemical Section of the British Association at Cambridge on June 23rd, 1845, in which he described the behaviour of gutta percha towards various chemical agents, alkalies, acids, &c., and on the very same day Dr. Douglas MacLagan⁵ sent a communication to the Royal Scottish Society of Arts at Edinburgh, in which he likewise dealt with the chemical properties of this substance, and gave the result of its ultimate analysis, which he considered sufficiently conclusive to justify the opinion that it is "generally the same as caoutchouc." A short

time after, Kent¹ and Soubeiran² found that commercial gutta percha contained two resinous substances, one soluble and the other insoluble in cold alcohol. Adriani³ and Arppe⁴ further examined these resinous components, and the latter distinguished quite a number of them, some being crystalline, others amorphous. The chemical analysis of these resins showed that they contained different amounts of oxygen. Payen,⁵ in 1852, came to the conclusion that purified gutta percha contained three proximate components, viz., a substance insoluble in cold and in boiling alcohol, which he termed *Pure Gutta*; a crystalline white resin, soluble in hot, but not in cold alcohol, which he called *Albane*; and lastly, an amorphous yellow resin which he named *Fluavile*.⁶

Later on, Oudemans⁷ and von Baumhauer⁸ showed that Payen's *Pure Gutta* was a hydrocarbon, having the composition $C_{10}H_{16}$ like caoutchouc, and therefore isomeric with oil of turpentine, and that the resinous components might be represented by the following formulæ, viz.: —*Albane* $C_{10}H_{16}O$, and *Fluavile* $C_{20}H_{32}O$. Quite recently, Mr. Otto Oesterle⁹ subjected gutta percha to a still more searching chemical analysis in Prof. Tschirch's laboratory at Berne, and found a fourth component, which he termed *Guttane*, and of which he gave the composition, after repeated precipitations by alcohol from a solution in chloroform, as C 86.4 per cent. and H 12.0 per cent.; it is, however, a very variable substance.

I myself had also repeatedly noticed the presence of this substance in gutta percha, but have not further examined it.

For albane, Mr. Oesterle finds the formula $C_{40}H_{64}O_2$, and for fluavile $(C_{10}H_{16}O)_n$; that is, he finds more oxygen in the latter than in the former, which is just the reverse of Oudemans' results.

My own analyses gave the following percentage composition:—

¹ Exhibited by the Hon. East Indian Company, *Musgrave's Chemistry*, vol. 2, p. 349.*

² *Journ. Agric. and Hortic. Soc., India*, 1843, vol. 2, p. 104.*

³ *Journ. Agric. and Hortic. Soc., India*, 1844, vol. 3, p. 147.*

⁴ *Pharm. Journ.*, 1845-46, vol. 5, p. 510.*

⁵ *The Edinburgh New Philos. Journ.*, 1845, vol. 39, p. 238.*

¹ *Silliman's American Journ. of Science and Arts*, 1848, Second Series, vol. 6, p. 246. *Jahresber. d. Chemie*, 1847-48, p. 744.*

² *Journ. de Pharm.*, 1848, 3me série, vol. 11, p. 17. *Jahresber. d. Chemie*, 1847-48, p. 742.*

³ A. Adriani, *Verhandelng over de Gutta Percha en Caoutchouc*, Utrecht, 1850.*

⁴ *Oefversigt of Kongl. Vetensk. Akad. Föreläsningar* 1850, vol. 7, p. 77; also *Journ. f. prakt. Chem.*, 1851, vol. 53, p. 171.*

⁵ *Comptes Rendus*, 1852, vol. 35, p. 107.

⁶ Specimens were shown.

⁷ *Rep. Chim. appliqué*, vol. 1, p. 455. *Jahresber. d. Chemie*, 1850, p. 517.*

⁸ *Journ. f. prakt. Chem.*, 1850, vol. 78, p. 277.*

⁹ *Archiv. der Pharm.*, 1892, vol. 230, p. 641.*

Albane.	Fluavile.
C = 78.96 per cent.	C = 80.79 per cent.
H = 10.58 „	H = 11.00 „
O = 10.46 „	O = 8.21 „
100.00 „	100.00 „

which corresponds to the formulæ:—albane $C_{10}H_{16}O$, agreeing with Oudemans' results; and fluavile $C_{40}H_{64}O_3$, agreeing neither with Oudemans' nor Oesterle's determinations; the composition of the latter resin seems to vary in different kinds of gutta percha.

and tenacious on cooling, without being in the least brittle. But the resins themselves are either soft at ordinary temperatures, or, when hard, quite friable. It is, therefore, the *gutta* which forms the valuable constituent of gutta percha, and the *resins* are only accessory components, which, although admissible, and perhaps even desirable in a comparatively small amount, yet have a decidedly detrimental effect when they preponderate. Hence in order to arrive at an opinion on the technical value of a sample of gutta percha, it is indispensable

FIG. 11.



EXTRACTION OF GUTTA FROM THE TRUNK IN SUMATRA.

Pure *gutta* is insoluble in ether and light petroleum spirit at ordinary temperatures, whereas both *albane* and *fluavile* dissolve readily in these menstrua. Either of these two solvents is therefore suitable for separating the resinous components from the hydrocarbon.

Gutta possesses all the good qualities of gutta percha, but in a much enhanced degree; it becomes soft and plastic¹ on heating, and hard

to determine the relative proportion or ratio between *gutta* and *resin*. But besides these two constituents, there are others which have to be taken into account—the mechanically-enclosed *water*, frequently reaching a high figure, and the coarser impurities, such as wood fibres, bark, sand, &c., which I briefly describe as *dirt*. The latter two components represent the loss or *waste* to the manufacturer on cleaning.

¹ The property of *pure gutta* of becoming plastic at higher temperatures, shows that it is not a simple body, but a mixture (alloy) of several hydrocarbons, differing probably

only in their molecular constitution. The case is similar to that of the tinman's solder in the state in which it is used for making what is technically called a "wiped joint."

We now see that it is necessary to determine for commercial purposes at least four

The water can be determined with sufficient accuracy for most practical purposes by gently

FIG. 12.

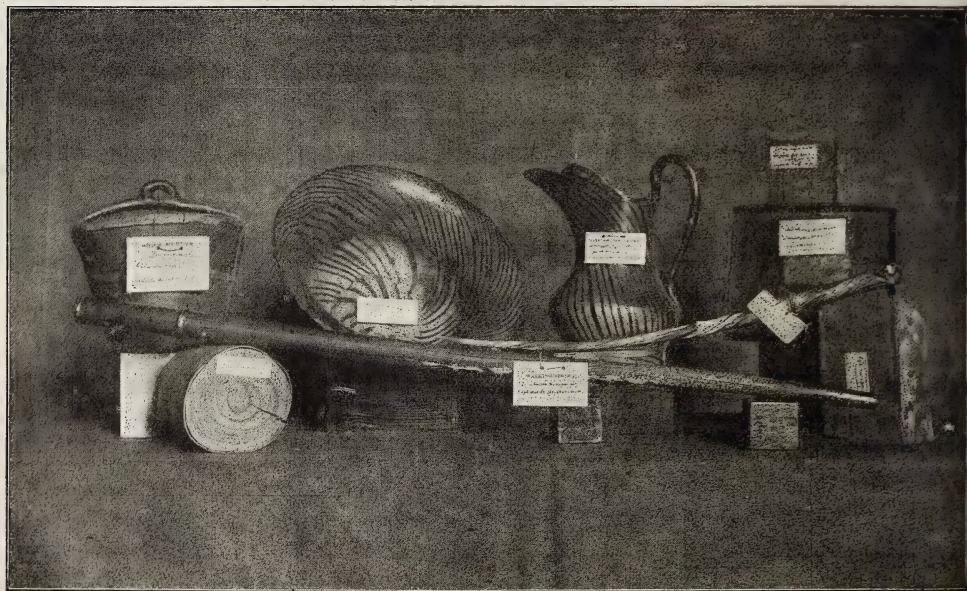


OBJECTS MOULDED IN GUTTA PERCHA.

proximate constituents in raw gutta percha, viz., water, dirt, resin, and gutta, and

heating a weighed quantity first in the open air, and then in vacuo over an absorbent substance

FIG. 13.



GUTTA PERCHA ARTICLES SHOWN AT EXHIBITION OF 1851.

the more we find of the latter, the better the material.

until no further loss occurs; but sometimes it has to be ascertained by direct weighing

The resinous components also might be determined from the loss of weight, after exhausting the dried material with ether or petroleum-spirit, but it is mostly desirable to weigh them directly after evaporation of the solvent. There now remains a mixture of gutta and dirt; these can be separated by treatment with carbon disulphide or chloroform, which dissolves the gutta and leaves the dirt behind, the latter being removed from the solution by filtration, washed and weighed. The gutta also is weighed after distilling off the solvent and drying in vacuo, but for greater accuracy it is precipitated from the solution by means of alcohol, when it can finally be obtained perfectly white and pure.

In the manner just described thousands of raw materials have been analysed in our laboratory since 1881, the year in which I first introduced this method for regular use, and in several instances we went even a step further, and separated the resins into *albane* and *fluavile*. But let me here add a word of caution. I stated that the relative proportion of gutta and resin forms an important criterion for estimating the commercial value of a material; but this in itself is not sufficient. Even putting aside for the moment the variable composition of the resinous components, there are guttas and guttas, and although the ultimate analysis of two different specimens may give exactly the same result, the physical and mechanical properties, and most important of all, the durability may widely differ, owing to a difference in their molecular constitution. It is therefore absolutely indispensable in addition to the quantitative determination of the components to scrutinize the gutta itself, which I need hardly say requires much judgment and experience.

As an illustration of such analyses, I have prepared Table I., showing the percentage composition of seven different specimens of gutta percha collected by Mr. Wray in Perak from definite botanical sources, and presented by him to Kew Gardens in 1883 and 1884.

The Table gives the names under which the plants are known to botanists, the habitat of the trees, and the Malay names of the gums they yield, under which they are known in Perak. It also contains a short description of the materials as received and of their constituent parts, gutta and resin. The figures obtained by analysis are worked out in two different ways, viz., in per cents. of the material as received, and of the gutta percha proper which it contains, to facilitate the comparison between different specimens.

TABLE I.—ANALYSIS OF GUTTA PERCHA OF KNOWN BOTANICAL ORIGIN.

Specimens collected by Mr. Leonard Wray, jun., in Perak, and presented to the Royal Gardens, Kew, 1883-4. (Analysed in 1885.)

No. of Specimen.	Botanical description of plant given by Mr. Wray.	Habitat of plant.	Native name of specimen, used by the Perak Malays.	Specimen as received.										Gutta Percha proper.				
				Appearance, &c.	Percentage composition.				Totals.			Ratios.		Percentage composition.		Quality.	Appearance of components.	
					Gutta G.	Resin R.	Dirt D.	Water W.	G. P. (G. + R.)	Waste (D. + W.)	G. P. Waste	Gutta Resin	Gutta g.	Resin r.	$\frac{r}{g}$		Gutta.	Resin.
1	<i>Dichopsis oblongifolia</i> (Burck.)	Ulu Kenering, 1884. (Upper Perak.)	Getah taban sutra (silkly)	Nearly white, clean.	84.3	10.7	3.7	1.3	95.0	5.0	19.0	7.9	88.8	11.2	1	Light brown, elastic	Yellow, very soft.	
2	<i>Dichopsis gutta</i> (Henth. & Hook.)	River Plus, 1883. (Upper Perak.)	Getah taban merah (red)	Very light, pinkish, clean.	77.1	16.9	4.6	1.4	94.0	6.0	15.7	4.6	82.0	18.0	10	Light, pinkish, elastic prime.	Brownish yellow, very hard.	
3	<i>Dichopsis polyantha</i> (Henth.)	Waterfall Hill, 1883. 2,500 ft. (Larut.)	Getah taban putih (white)	White, clean.	47.0	48.4	3.6	1.0	95.4	4.6	20.7	1.0	49.3	50.7	5	Light brown, elastic.	Light brown, brittle.	
4	<i>Dichopsis pustulata</i> (Hemsley.)	Waterfall Hill, 1884. 600 ft. (Larut.)	Getah taban chaier (liquid)	White, dense, clean.	45.3	49.6	3.4	1.7	94.9	5.1	18.6	0.9	47.8	52.2	5 ^a	Light brown, elastic.	Light brown, very brittle.	
5 ^a	<i>Dichopsis Maingayi</i> (Clarke.)	Changkat S'rdang, 1884. (Larut.)	Getah taban simpor	Nearly white, clean, crumbly.	23.1	71.5	4.2	1.2	94.6	5.4	17.5	0.3	24.4	75.6	7 ^b	Light, pinkish, elastic.	Very light, hard.	
6	<i>Payena Leeri</i> (Burck.)	Saptang, near coast (Larut.)	Getah sundek.	Nearly white, dense, clean.	43.9	37.6	5.1	13.4	81.5	18.5	4.4	1.2	53.9	46.1	4 ^b	Light, pinkish, elastic.	Pale yellow, nearly liquid.	
7	<i>Bassia Modleyana</i> (Clarke.)	Waterfall Hill, 1884. 2,000 ft. (Larut.)	Getah gahru.	Nearly white, clean, crumbly.	31.6	65.2	1.8	1.4	96.8	3.2	30.2	0.5	32.6	67.4	6 ^c	White, very brittle.	Light, hard.	

* Another and larger sample of Getah taban simpor from Dichopsis Maingayi, sent to Kew by Mr. Wray in 1886, and recently analysed, gave 93.5 per cent. G.P., consisting of one part gutta and two parts resin (quality 6^c), and being therefore notably better than the former specimen.

In the present instance the percentages of water and dirt are only of secondary interest, and it is chiefly the two columns headed "Gutta" and "Resin" and marked (g) and (r) to which I would direct your attention. You observe the very great difference in the relative amount or "Ratio" of these two components in different specimens. Take, for instance, No. 1 from *Dichopsis oblongifolia*, which contains eight times as much gutta as resin, and compare it with No. 3 from *Dichopsis polyantha*, containing about an equal amount of both, and, further still, with No. 5 from *Dichopsis Main-gayi*, where the amount of resin is three times that of gutta. Materials in which the percentage of resin reaches that of gutta, or even surpasses it, are of a decidedly inferior description, and you observe that four out of the seven samples from Perak belong to this category. Of the remaining three, the first two from *Dichopsis oblongifolia* and *Dichopsis gutta* are of excellent quality, whereas the third—i.e., spec. No. 6, "Getah sundek" or "soondie," from *Payena Leerii*—is decidedly inferior to these.

Next to the two columns marked "Gutta" (g) and "Resin" (r) respectively, there is one headed "Quality" (q) and I owe you a word of explanation for these values which were introduced by me some years ago for the sake of convenience at our works.

As I have told you the commercial value of gutta percha depends principally on the relative amounts of gutta and resin contained therein, and it occurred to me to utilise this fact for the division into qualities. Taking 10 lbs. as the standard weight of gutta percha proper, I designate its quality as first, second, third, &c., if the amount of resin contained therein is 1 lb., 2 lbs., 3 lbs., &c., respectively (the percentage of resin divided by 10, e.g., $q = \frac{r}{10}$). This division alone, however, would be too coarse, even for practical purposes, and I consequently subdivide the interval between two consecutive qualities into $\frac{1}{4}$ lbs., and distinguish them by affixing the letters a, b, and c. If, therefore, a material is described as being of 3^a quality, it means that the gutta percha proper, contained in it has $3\frac{1}{4}$ lbs. of resin, or thereabouts, in every 10 lbs. (32.5 %), if another is called 5^b it contains $5\frac{1}{2}$ lbs. (55 %), &c. Qualities with less than 1 lb. of resin (10 %) very rarely occur in commercial raw samples,¹ but are described as

Oa, Ob, Oc if containing $\frac{1}{4}$, $\frac{1}{2}$, and $\frac{3}{4}$ lbs. (2.5, 5.0, 7.5 %) of resin respectively, when artificially produced. Even with this subdivision the description of the quality admits of a certain variation in the percentage of resin in both directions, and this is a decided advantage for practical purposes where it is not always desirable to be too strict. The ratio Gutta Resin also given in the Table, although excellent for descriptive purposes, is somewhat too sensitive for the factory, and not so descriptive.

Of the small specimens of gutta percha recently received from Haarlem, and which had been obtained from the various trees cultivated at Tjikeumeuh, and experimentally tapped about 10 years after they had been planted, only those from *Palaquium Borneense* and *Payena Leerii* were still in a sufficiently good state of preservation for analysis; whereas the others from *Palaq. gutta* and *Palaq. Treubii* had been already badly oxidised.

The composition of the specimen from *Palaq. Borneense* was found to be intermediate between that of *Palaquium (Dichopsis) gutta* and *Palaq. oblongifolium* from Perak (given in Table I.), as it contained 85.3 per cent. of gutta and 14.7 per cent. of resin in the gutta percha proper. The specimen from *Payena Leerii* agreed fairly well in composition with that from Perak, giving 54.8 per cent. gutta and 45.2 per cent. resin, the difference between the two being negligible, for practical purposes.

I shall now give you the results of analyses of several materials which were described either as Getah *taban* or *merah* or both, and for comparison that of a small piece of homogeneous pinkish material, which I picked out from a large commercial lot of first-class, as resembling in appearance this class of gutta percha and you observe that as far as quality is concerned, there is not much difference between the four materials, so that we may consider the average as representing the gutta percha known as *Getah taban merah*.

The second part of Table II. affords a similar comparison for various specimens received under the name of *Getah mantah*, *sundek*, *sondek*, or *soondie*. Here again the mean of the figures fairly represents the average composition of this particular kind of second-class gutta percha.

Table III. which now follows is particularly interesting as showing the composition of some historical specimens of gutta percha, one sen

¹ The lowest amount of resin hitherto found by me in the gutta percha proper of a commercial raw sample is 11.9 per cent., corresponding to quality 1^a.

TABLE II.—ANALYSIS OF SPECIMENS OF GETAH TABAN (MERAH) AND GETAH SOÓNDIE RECEIVED FROM VARIOUS SOURCES.

Type of Gutta.	Description of Specimen.		Specimen as received.							Gutta Percha proper.						
	Name.	Source.	Appearance.	Percentage composition.			Totals.		Ratios.		Percentage composition.	Quality.		Appearance of Components.		
				Gutta G.	Resin R.	Dirt D.	Water w.	G.P. (G. + R.)	Waste (D. + W.)	G.P. Waste.		Gutta Resin R. sin.	Gutta G.		Resin R.	$\left(\frac{r}{10}\right)$
Gutta	Gutta Taban (from Solangor). Pahang Taban.	Col. and Indian Exhibition, 1886 (Straits Settlements). Singapore Market, 1890.	Very light, pinkish, not dense.	75.5	13.5	2.0	9.0	89.0	11.0	8:1	5:6	84.8	15.2	1b	Light pinkish brown.	Hard, dark brown.
	Gutta Taban Merah (Dichapsia Gutta, Benth.). Pahang A.	H. N. Ridley, Esq., F.L.S. (Singapore, 1892). Homogeneous piece picked out from large lot, 1897.	Very light, clean, not dense.	68.8	10.1	5.4	45.7	78.9	21.1	3.7	6.8	87.2	12.8	1a	Very light, brown, strong.		Nearly hard, light brown.
Taban (Merah)	Gutta Taban Merah (Dichapsia Gutta, Benth.). Pahang A.	H. N. Ridley, Esq., F.L.S. (Singapore, 1892). Homogeneous piece picked out from large lot, 1897.	Light pinkish br., clean, dense	66.7	14.0	6.2	13.1	80.7	19.3	4.2	4.8	82.6	17.4	1c	Light pinkish, very strong.	Hard, reddish brown, translucent
	Gutta Taban Merah (Dichapsia Gutta, Benth.). Pahang A.	H. N. Ridley, Esq., F.L.S. (Singapore, 1892). Homogeneous piece picked out from large lot, 1897.	Pink, dense, little fine bark.	66.2	11.6	13.2	9.0	77.8	22.2	3.5	5.7	85.1	14.9	1b	Very light brown, strong.	Hard, very dark brown.
Gutta	Gutta Mantah (from Borneo). Gutta Sundek (Pavona Leerii). Getah Sondek (Pavona spec.). Goolie Soondie (from Bagan).	James Collins, Esq., 1886 (Kew Gardens). Sir Hugh Low, Perak, 1885 (Kew Gardens). H. N. Ridley, Esq., F.L.S. (Singapore, 1892). Homogeneous pieces picked out from large lot, 1897.	Very light, crumbly, clean.	50.8	38.9	9.3	1.0	89.7	10.3	Mean		84.9	15.1	1b	Very light, brownish	Hard, yellowish brown.
	Gutta Mantah (from Borneo). Gutta Sundek (Pavona Leerii). Getah Sondek (Pavona spec.). Goolie Soondie (from Bagan).	James Collins, Esq., 1886 (Kew Gardens). Sir Hugh Low, Perak, 1885 (Kew Gardens). H. N. Ridley, Esq., F.L.S. (Singapore, 1892). Homogeneous pieces picked out from large lot, 1897.	Very light, dense, clean.	46.4	34.7	2.6	16.3	81.1	18.9	8.7	1.3	56.6	43.4	4a	Nearly colourless.	Very soft, light brown.
Soondie	Gutta Mantah (from Borneo). Gutta Sundek (Pavona Leerii). Getah Sondek (Pavona spec.). Goolie Soondie (from Bagan).	James Collins, Esq., 1886 (Kew Gardens). Sir Hugh Low, Perak, 1885 (Kew Gardens). H. N. Ridley, Esq., F.L.S. (Singapore, 1892). Homogeneous pieces picked out from large lot, 1897.	Very light, dense, clean.	43.0	32.6	5.1	19.3	75.6	24.4	3.1	1.3	56.9	43.1	4a	Nearly white, very strong.	Very soft, light brown.
	Gutta Mantah (from Borneo). Gutta Sundek (Pavona Leerii). Getah Sondek (Pavona spec.). Goolie Soondie (from Bagan).	James Collins, Esq., 1886 (Kew Gardens). Sir Hugh Low, Perak, 1885 (Kew Gardens). H. N. Ridley, Esq., F.L.S. (Singapore, 1892). Homogeneous pieces picked out from large lot, 1897.	Very light, dense, clean.	51.5	38.3	2.8	7.4	89.8	10.2	8.8	1.3	57.4	42.6	4a	Very light brown, very strong.	Soft, light yellow.

TABLE III.—ANALYSES OF HISTORICAL SPECIMENS OF THE COAGULATED LATEX OF *Isonandra Gutta* (HOOKER).

No. of specimen.	Year of collection.	Name of Collector.	Locality.	Name of Donor.	Particulars of specimen.	Appearance of specimen.	Material (after drying in vacuo).				Gutta Percha proper.					
							Percentage composition.		Total.	Ratio.	Percentage composition.		Quality			
									G.P. (G. + R.)							
							Gutta G.	Resin R.	Dirt D.	Gutta Resin	Gutta g.	Resin r.	Quality (r/g)	Appearance of components.		
1	1846	Lobb	Johor ¹	Kew Herbarium	2 Piece from riding whip, sent with dried specimen (No. 209) to Sir William Hooker, and described by him as <i>wood</i> .	Very light, hard fibrous, showing ebony black lines	79.4	17.6	3.0	97.0	4.5	81.8	18.2	1c	Gutta.	Resin.
2	1847	Oxley	Bukit Timah, Singapore	Kew Museum	3 Cover of tin box in which flowering branch of <i>Asmandra gutta</i> was sent to Sir William Hooker.	Dark brown, hard, containing dirt and small pieces of bark	71.5	24.2	4.3	95.7	3.0	74.6	25.4	2b	Light brown, strong	Light yellow, soft
3	1887	Sérullas	Bukit Timah, Singapore	M. Sérullas	4 Coagulated <i>latex</i> from offspring of same tree as Lobb's botanical specimen.	Light brown, hard	75.6	8.3	16.1	83.9	9.1	90.1	9.9	1	Light brown, not very strong	Light yellow, soft

¹ So described on slip of paper found with another of Lobb's specimens in the Herbarium. A specimen from Johor, collected about seven years ago, and recently analysed, contained 90 per cent. gutta percha proper, with only 8 per cent. resin (quality O').

Lond. Journ. Bot., 1847, vol. 6, p. 33.

³ *Lond. Journ. Bot.*, 1847, vol. 6, p. 404.

¹ *Lum. Electr.*, 1890, vol. 38, p. 411. This

Lum. electr., 1890, vol. 38, p. 411. This specimen contained 5.7 per cent. water.

to Sir Wm. Hooker by Lobb in 1846, and the second by Oxley in 1847, both being described as having been obtained from the same tree as the botanical specimens which they accompanied. The third specimen is the one collected in 1887 by Sérullas at Bukit Timah from an offspring of Oxley's tree, as already mentioned, the corresponding botanical specimen being also here to-night. The comparatively large amount of resin in Oxley's specimens is noteworthy, as is also the marked difference between this and Sérullas' specimen, which latter contains an exceptionally low amount of resin. It may be that the great age of Oxley's specimen and its long exposure to air and light in the museum has something to do with this as it is badly oxidised on the surface, whereas the still older specimen from Lobb, which had been protected from light in the Herbarium, is still in an excellent state of preservation.

The specimen collected at Johor about seven years ago, contains even less resin than that from Sérullas, showing that excellent trees must have existed at that time, and probably still exist in that district.

But we must now leave the specimens of scientific interest and consider the commercial materials. These are mostly designated according to the names of either the producing countries, or the places whence they are exported. Examples of the former have such designations, for instance, as *Pahang*, *Bulongan*, *Sarawak*, &c., and of the latter, *Bagan*, *Serapong*, *Macassar*, &c. Of the numerous sorts which appear on the Singapore market from time to time, I can only deal with the principal ones,¹ and I have selected the following twelve *brands* as typical of the rest of them, and divided them into four groups for convenience in comparison and reference, as follows:—

1st Group, comprising the three best kinds of gutta percha, probably all derived from some species of *Palauquium* closely related to *Pal. gutta* and *Pal. oblongifolium*:—

1. Pahang, from the Malay Peninsula.²
2. Bulongan red, from Borneo.
3. Banjer red, from Borneo.

2nd Group, comprising three kinds of gutta percha of the second order, probably all derived

from some species of *Payena*, possibly from *Payena Leerii*:—

4. Bagan goolie (and gutta) soondie, from Borneo.
5. Goolie red soondie, from Borneo.
6. Serapong goolie soondie, from Sumatra.

[NOTE.—Gastric red soondie appears to be identical with Kataringin gastric soondie.]

3rd Group, comprising three kinds of so-called "white gutta" of second and third class from unknown trees, possibly partly from *Dichopsis polyantha* or *pustulata*, and partly from some species of *Payena*:—

7. Bulongan white, from Borneo.
8. Mixed white "
9. Banjer white "

4th Group, comprising three "mixed" materials, two of them being what is termed "reboiled" (an operation performed by the Chinese, who buy up odd lots, soften the materials in hot water, and make them into a more or less homogeneous average mixture):—

10. Sarawak mixed, from Borneo.
11. Padang reboiled, from Sumatra.
12. Banca reboiled, from Banca.

[NOTE.—The mixed Sarawak lots mostly represent a very useful second-class material; the two reboiled are decidedly inferior.]

The average composition of the various commercial brands is graphically represented by Diagram¹ (p. 129), Fig. 14, each value being deduced from the analysis of a great number of individual lots, taking into account their relative weights. Altogether 2,282 tons of raw gutta percha are represented by the figures in this Diagram, and 751 analyses of individual lots.

The calculation of the mean values from the percentage composition of each lot was, as you may imagine, a rather laborious task.

The Diagram is so arranged that the components are, as it were, piled one on top of the other: first the gutta, indicated by cross shading; next the resin, shown by oblique lines; then the dirt, by horizontal; and finally the water, by vertical lines. The height of the black column at the side represents the percentage of "gutta percha proper" contained in the raw material, and, consequently, the empty space above shows the "waste." The small white dot indicates by its elevation above the datum line the ratio between pure gutta and resin, *i.e.*, the character of the gutta percha—quantity and character combined being the essential factors for estimating the value of a sample.

¹ Analyses of samples of several brands of gutta percha have been published by M. Léon Brasse in 1892. *La Lum. électr.*, 1892, vol. 46, p. 51.*

² The name of "Pahang" gutta percha is now applied to any first-class material, irrespective of its geographical derivation.

¹ The figures will be given in a Table in the Appendix.

For a comparison of different materials it suffices therefore to observe the length of the black column, and the height of the white dot

at once that the members of the first group, although not remarkable for great length of the black column, are yet distinguished from all

FIG. 14.

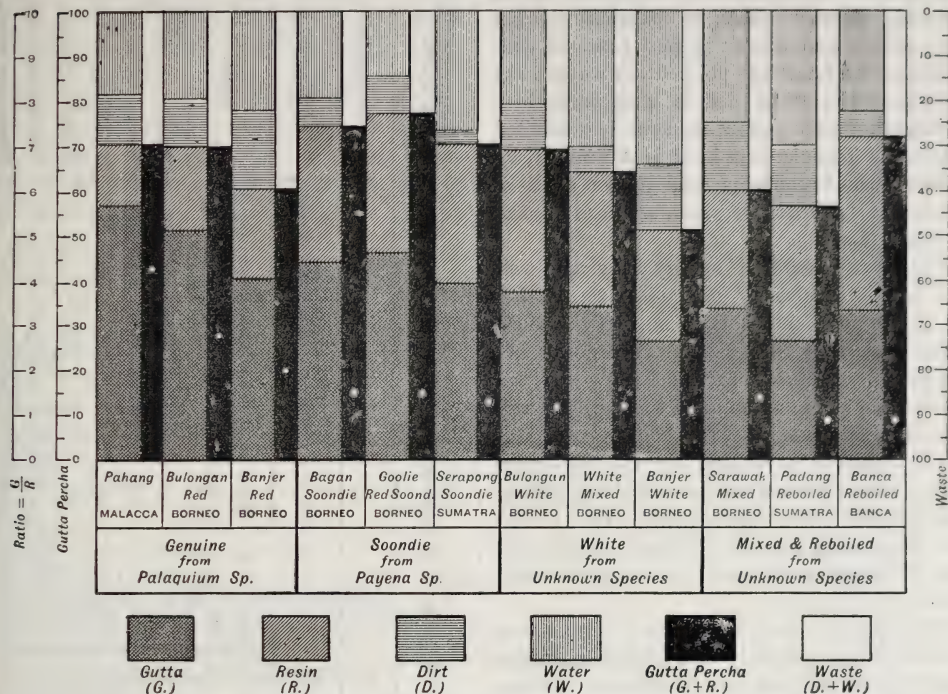


DIAGRAM SHOWING COMPONENTS OF GUTTA PERCHA.

FIG. 15.

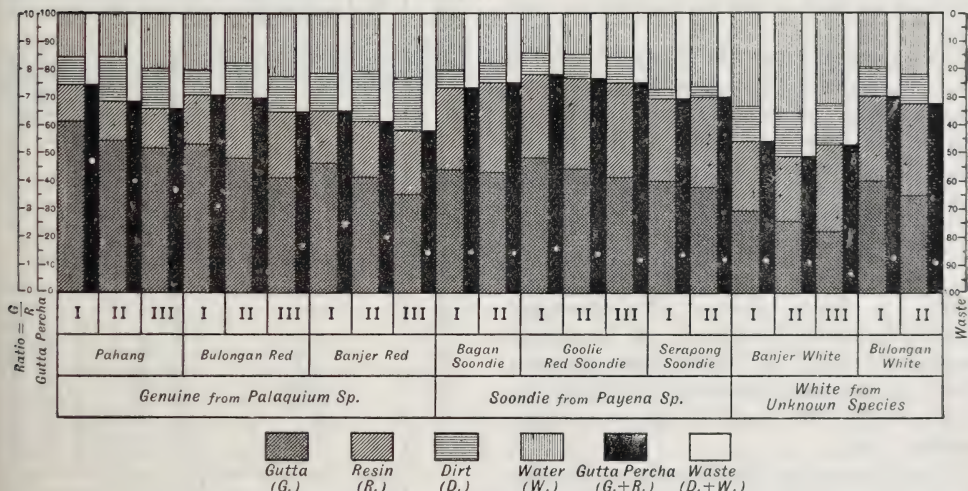


DIAGRAM SHOWING COMPONENTS OF GUTTA PERCHA.

above the datum line. The division of the different brands into four distinct groups is also shown on the Diagram, and you observe

others by the greater elevation of the white dot, indicating a favourable ratio between pure gutta and resin. Other materials, on the

The result of the analyses of these samples bears this out, except in the case of the sample from Lampong, the southernmost part of Sumatra, which only represents a second-class material, so it may just be possible that the southern limit of the area, viz. 6°, is too great, although, of course, no definite conclusion can be drawn to that effect. On the other hand it is interesting to observe that the sample from Achin, situated beyond the western boundary of the area, yielded an excellent material, and although the quantity imported into Singapore from Achinese ports during the last 12 years was only 15 cwts.,

very brief, as the more generally interesting particulars have been represented by Diagrams, whilst the detailed information will be given in the Appendix.

The Diagram (Fig. 16) shows the quantity and value of raw gutta percha imported into Singapore, the chief market-place of this article, for each year from 1885 to 1896, from the principal producing countries, and you will observe the extraordinary fluctuations. Look, for instance, at the quantity imported from Sumatra in 1889, amounting to over 39,000 cwts., and compare it with that in the following year, which is only little more than

FIG. 16.

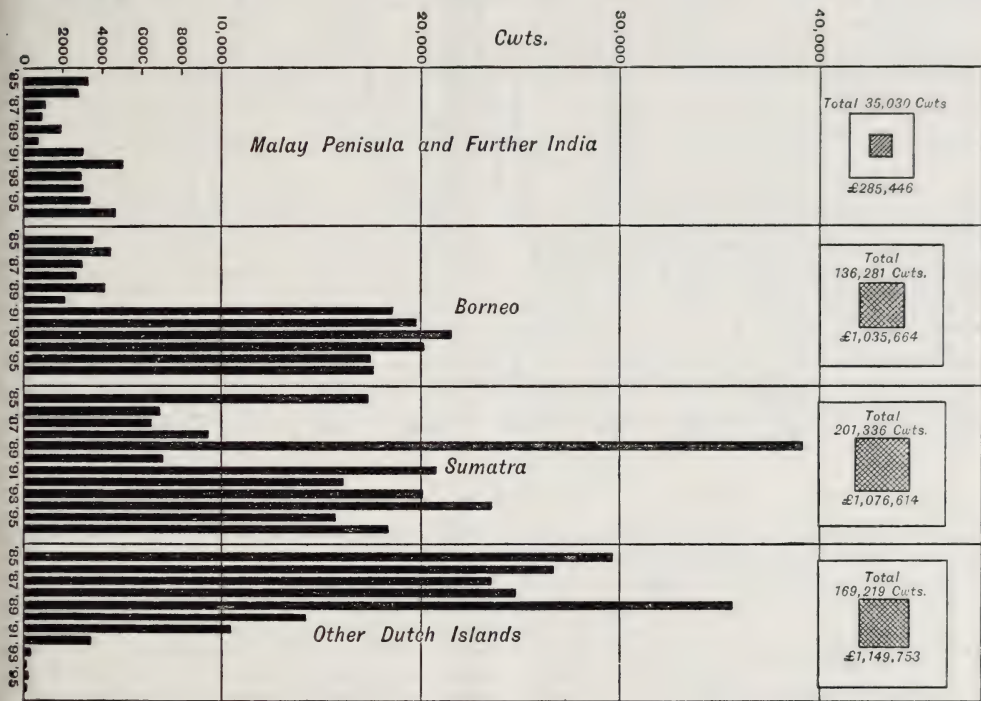


DIAGRAM SHOWING IMPORTATION OF GUTTA PERCHA TO SINGAPORE.

yet the price paid for it was a high one, viz., over 2s. per pound.

Here it is therefore possible, that the western boundary of the area ought to be extended, and considering that the northern part of Sumatra is as yet hardly explored, it is quite possible that it will have to be extended in the future to the dotted line shown on the map.

IMPORTS INTO AND EXPORTS FROM SINGAPORE.

I have now arrived at the last section of my programme for to-night, the *statistical* and *financial* part of the subject. Here I can be

7,000 cwts. Also look at the import from "Other Dutch Islands" in 1889, which is over 35,000 cwts., whereas five years later, it is reduced to only 63 cwts. The shaded squares on the Diagram represent the total imports into Singapore during the 12 years from each particular country, and the larger shaded squares the corresponding values. The largest amount during this period came from Sumatra, but the total value of the import from Borneo is only about 4 per cent. lower than that from the first-named island, whilst the quantity is 20 per cent. lower, which is significant of the respective qualities of the materials.

FIG. 17.

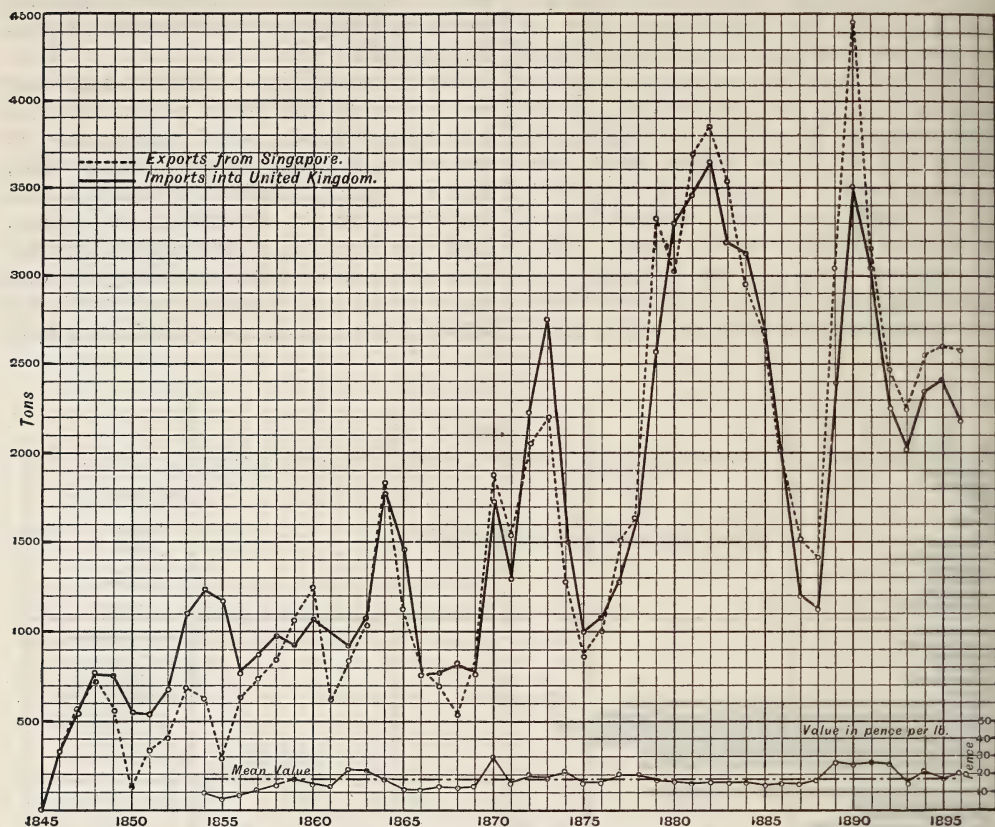


DIAGRAM SHOWING EXPORTS AND IMPORTS OF GUTTA PERCHA.

FIG. 18.

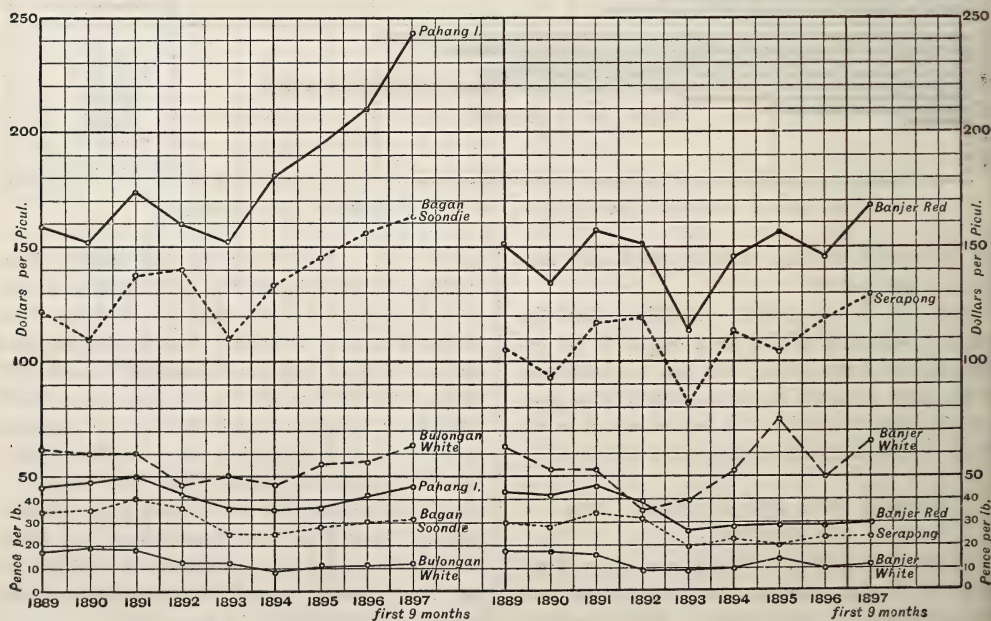


DIAGRAM SHOWING EXPORTS AND IMPORTS OF GUTTA PERCHA.

Table V. gives the imports into Singapore for the last five years (1892 to 1896) from the various districts of Borneo and the Malay Peninsula; it also shows the values per lb. in pence. This enables you to form an opinion about the relative *quality* of the materials produced in the various districts. Compare, for instance, the values per lb. for Penang and Kelantan.

TABLE V.—IMPORTS INTO SINGAPORE DURING LAST FIVE YEARS (1892-1896).

	Quantity. Cwts.	Value. £.	Value per lb. Pence.
BORNEO.			
Brit. North Borneo	4,201	26,240	13'4
Brunei	279	2,279	17'5
Sarawak	14,232	115,842	17'5
Borneo proper.....	76,688	560,145	15'7
Labuan	1,443	11,162	17'3
Sulu Archipelago ...	255	1,347	11'3
MALAY PENINSULA.			
Penang	11,298	120,560	22'9
Perak	344	2,378	14'8
Selangor	776	5,756	15'9
Sungei Ujong	189	1,454	16'5
Malacca	336	2,206	20'0
Johor	646	5,342	17'7
Pahang	2,389	15,911	14'3
Tringganu	2,088	12,645	13'0
Kelantan	1,254	7,030	12'0

The dotted curve (Fig. 17, p. 132) shows the quantity of raw gutta percha exported from Singapore during each year from 1845 to 1896.

The total export of gutta percha from Singapore up to the end of last year is 82,716 tons, and that during the last 12 years (1885-1896) alone 30,757 tons, of which 23,539 tons, representing a total value of £3,810,917, were sent to England.

IMPORTS INTO THE UNITED KINGDOM AND FLUCTUATION OF PRICES.

The yearly imports into the United Kingdom from various specified countries is given in a Table in the Appendix, but the total amounts are also graphically represented in Fig. 17 (p. 132) by a continuous line. The two curves representing the export from Singapore and import into the United Kingdom are on the whole concomitant, thus showing that the gutta percha exported from that place mostly came to these islands, but there are some interesting features which should not be passed over. Thus, in the year 1873, the imports to Great Britain largely ex-

ceeded the exports from Singapore. In that year a large quantity of gutta percha was imported to England from Holland whither it had been brought direct from the Dutch Indies. A good deal was also purchased from other European countries, which was originally obtained from Singapore. The high peak in the curves occurring in 1882 is largely due to the Atlantic cables manufactured at that time, and shows the great influence which the cable manufacture has had on the import of gutta percha. Another significant feature is the increased distance between the two curves during later years, owing to the greater quantity of material used by other countries.

The curve at the lower part of Fig. 17 shows the annual fluctuation of the value per lb. as deduced from the quantity and total value for each year. The horizontal line consisting of dots and dashes represents the mean value during the period here considered—viz., from 1854 to 1896, which is 17'88 pence.

It is readily seen that the average value per lb. for any particular year does not only depend upon the price of a standard material, but also largely upon the relative proportion of superior and inferior gutta percha imported during that period.

I, therefore, thought it would be useful and instructive to show some further curves which represent the fluctuations of price on the Singapore market for certain recognised *brands* of the material.

Diagram, (Fig. 18), graphically represents these particulars for six different brands, mostly of first grade, during the last nine years, the figures themselves will be given in the Appendix.

The prices are given both in *dollars per picul* (133½ lbs.) and in *pence per lb.*, to show how greatly the rate of exchange influences the price which the manufacturer has to pay for his material. That the variations in the exchange may sometimes apparently reverse the actual conditions, can be seen, for instance, from the prices of "Pahang" in 1893 and 1894 respectively. As the curves show, the price per picul in these two years was \$152 and \$180 respectively, whereas that per lb. was 36'76d. and 35'2d., the value of the dollar having fallen from 32'22d. to 25'92d., or about 20 per cent., during that particular period.

We have now followed the gutta percha from its existence in the latex of the plant until it reaches the works, and in our next lecture we shall see how the manufacturer receives and treats the material.

Correspondence.

METALLURGY AND METAL MINING IN AMERICA.

As bearing upon some points in my paper delivered before the Society on November 24th, certain statistics given by Mr. John Birkinbine in a recent communication to the American Institute of Mining Engineers are worth repeating. He considers that:—

“Conservative estimates made of the explored and developed properties, indicate that there is practically, ‘in sight’ in the Mesabi range, double the amount of iron ore that has been shipped from the entire Lake Superior region during the past forty years of active development.”

With regard to the average value of the ore at the Lake Superior mines, he gives the following figures:—

“In the eight years for which statistics of domestic iron ore production have been collected under the authority of the general government, the output ranged from eleven and a half to sixteen million tons, the average for the eight years approximating fifteen million tons. The average value per ton of ore at the mines, however, has shown a marked decline. This value, in the years named, was as follows:—

Years.	Dols.
1889 the average value per long ton of ore was	2.30
1892 ” ” ” ”	2.04
1893 ” ” ” ”	1.66
1894 ” ” ” ”	1.14
1895 ” ” ” ”	1.14
1896 ” ” ” ”	1.42

The ‘ore-pool’ maintained prices for much of 1896; hence the apparent advance in that year.”

This low cost of ore at the mines is, however, more than doubled by transportation charges, as the transportation involves more transfers than is usually supposed. Upon this point he makes the following interesting statement:—

“It is not necessary to detail in this paper the wide distribution of ores from the Lake Superior region, which now contributes five-eighths of the annual production of domestic iron ore. Let it suffice to say that, taking into account all the ore mined in this district, the average transportation by rail and water exceeds 800 miles between mine and furnace, and probably three-fourths of this ore is subjected to three, and sometimes four, transfers between the time when the loaded cars leave the mine and the time when other cars deliver the ore at the furnaces. That is, a large proportion of the ore mined in the Lake Superior region is loaded on cars which, after covering 15 to 100 miles of railroad-haul, are discharged into the pockets of ore docks. The pockets hold the ore until vessels are ready for cargoes. When the receiving docks of the lower lakes are reached, the ore is removed from the vessels into cars, or placed in stock piles, from which cars are loaded subse-

quently, as the consumers require the ore, and is finally unloaded at the furnaces.

“If, in addition, we consider the loading of ore underground in mine trams and skips, the hoisting of the same to the surface, the dumping of skips into shipping pockets or stock piles—in some cases sorting the ores—and the subsequent loading of railroad-cars at the mines, the number of transfers of much of the ore obtained in the Lake Superior region is from five to ten. Where steam shovels are employed in open cuttings, the handlings may be reduced; but notwithstanding this apparent economy, ores can only be mined and carried for the distances above named by the employment of efficient machinery, appliances, and management, when the basis price for Bessemer ore (yielding, when dried at 212° Fahr., 63 per cent. of iron and phosphorus 0.045 per cent.) at the receiving docks at the lower lake ports is \$2.40 per long ton.”

That the low cost at which pig iron is now being produced is largely due to the elimination of hand labour the following quotation from the same paper indicates:—

“The writer lately had opportunity to examine the labour accounts for three consecutive months connected with the mining of coal, coking of the same, mining of ore, transporting raw materials to furnace, the production of pig iron, and the delivery of the same on cars. The total number of days’ labour at mines, ovens, furnace, and proper proportion for railroad transportation, divided by the total tons of pig iron produced, gave a quotient less than four. That is, pig iron is now being produced in the United States for less than four days’ labour per ton of metal, from the time the native materials are attacked underground, to the delivery of the pig metal on cars for shipment. Such is the competition which the miners of ores must be prepared to meet. The books of another blast-furnace plant showed that 3½ tons of pig iron were produced for each day’s labour connected with the furnace. In each of the above instances, every *employé* outside of the office force was included in the total; and while each record may be considered as exceptional at the present time, they set a standard which all engaged in the production of pig iron must expect to meet. Those who supply ore, as well as those who smelt it, must be able to reduce their labour costs to a minimum.”

A further quotation from the presidential address of Mr. Spilsbury, before the American Institute of Mining Engineers, may be of interest. It has been generally known that Mr. Edison has of late devoted most of his time and energies to the erection of a very elaborate plant for the concentration of some of the leaner iron ores of New Jersey. Upon this subject Mr. Spilsbury says:—

“I cannot well leave this branch of my subject without calling to your attention the remarkable work in the mining, crushing, concentrating, and finally briquetting of magnetic iron ore, which is

carried on at the Ogden mine in New Jersey by Mr. Thomas Edison. As a theoretical development and improvement of the very highest type, these works of his stand out unique; but it has not yet been demonstrated in regular practice that the enormous outlay called for by such a complete plant—the present plant at Edison being reported as involving already an expenditure of one and a half million dollars—would be warranted, except in very exceptional cases. The experiments so far carried out on some 30,000 tons of rock have demonstrated the fact that an ore averaging not over 30 per cent. of iron can be quarried or mined, transported by rail a quarter of a mile to the mill, there crushed, sized, and re-crushed to a fine powder, the magnetic iron separated from the non-magnetic gangue, the concentrates mixed with a binder, then pressed into briquettes, furnace-dried and loaded on cars—all for less than six cents per unit of the iron contents of the briquettes. Even under the present conditions of low prices, if the resulting concentrates were low enough in phosphorus to bring them within the Bessemer limit, the operation could be carried on to a financial success; but, unfortunately, this is not the case, and therefore, until the price of foundry-pig shall advance to a figure at which it will be profitable to purchase of 68 per cent. iron ore at six cents a unit, it is not probable that the Edison works can be run continuously at a profit. It stands, nevertheless, a monument of perseverance in original research which certainly deserves our admiration."

JAMES DOUGLAS.

99, John-street, New York.
December 13th, 1897.

General Notes.

BARCELONA EXHIBITION, 1898.—The Secretary has received from the Science and Art Department information respecting the Fourth General Exhibition of Fine Arts and Artistic Industries to be held at Barcelona in 1898, which has been communicated to the Foreign-office by Her Majesty's Consul at Barcelona. The Exhibition will be precisely similar to that held in 1896, and artists from the countries of Europe are invited to contribute specimens of their work. The Fine Arts Section will include paintings, drawings, engravings, sculpture, carving in relief, architecture, and reproductions of classic works in painting, sculpture, &c. The Section of Artistic Industries will cover metal, silver, and locksmiths' work, jewellery, clay and glasswork, porcelain, china, pottery, &c., artistic carpentry and upholstery, artistic tapestry, worked leather, lace, &c. By Article X. it is enacted that the works of foreign artists will be admitted free of all expense to them as regard transport to Spain and back to the country of origin. The Exhibition will be open from 23rd April to 28th June.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

JANUARY 19.—"The Projection of Luminous Objects in Space." By ERIC STUART BRUCE, M.A.

JANUARY 26.—"Fireproof Construction of Domestic Buildings." By THOMAS POTTER.

FEBRUARY 2.—"The Cinematograph." By JULES FÜRST.

FEBRUARY 9.—"Compensation to Workmen." By A. D. PROVAND, M.P.

FEBRUARY 16.—"The Protection of Industrial Property." By J. F. ISELIN, M.A., LL.M.

Dates to be hereafter announced:—

"Kites: their Theory and Practice." By Captain B. F. S. BADEN-POWELL.

"Stage Mechanism." By EDWIN O. SACHS.

"The Recent History of Papermaking." By CLAYTON BEADLE.

"The Preparation of Meat Extracts." By C. R. VALENTINE.

"Children's Sight." By R. BRUDENELL CARTER, F.R.C.S.

"The Production of Low Temperatures." By Professor J. A. EWING, F.R.S.

"Aerial Telegraphy." By Professor SILVANUS P. THOMPSON, F.R.S.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock:—

JANUARY 20.—"Recreations of an Indian Official." By the Right Hon. Sir MOUNTSTUART ELPHINSTONE GRANT DUFF, G.C.S.I., C.I.E., F.R.S.

FEBRUARY 17.—"The Plague in Bombay." By HERBERT MILLS BIRDWOOD, C.S.I., M.A., LL.D. (late Governor's Council, Bombay).

MARCH 10.—"India and Sir Henry Maine." By CHARLES LEWIS TUPPER, C.S.I. The Right Hon. MOUNTSTUART ELPHINSTONE GRANT DUFF will preside.

MARCH 31.—"The Earthquake in Assam." By HENRY LUTTMAN-JOHNSON, I.C.S.

APRIL 21.—"The Rise, Progress, and Present Position of the Native Press of Western India." By R. P. KARKARIA (of Bombay).

APRIL 28.—"India and Currency." By Sir EDWARD SASSOON, Bart.

MAY 19.—Paper by Sir ALFRED COMYNS LYALL, G.C.I.E., K.C.B., D.C.L. (Member of the Council of India). (Title to be announced.)

The meetings of January 20, February 17, and March 31, will be held at the Imperial Institute; those of March 10, April 21, April 28, and May 19 at the Society of Arts.

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesday afternoons at 4.30 o'clock:—

JANUARY 18.—“My Recent Journey from the Nile to Souakim.” By FREDERIC VILLIERS.

FEBRUARY 15.—“The Goldfields of Klondyke and British Columbia.” By W. HAMILTON MERRITT.

Dates to be hereafter announced:—

“The African: what he is, and what he is capable of becoming.” By the Rev. GODFREY DALE (Universities Mission to Central Africa).

“The Sugar Industry in the West Indies.” By F. R. TUFNELL.

APPLIED ART SECTION.

The meetings of this Section will take place on the following Tuesday evenings, at 8 o'clock:—

JANUARY 25.—“Renaissance Woodwork in England.” By J. HUNGERFORD POLLEN. WILLIAM LUSON THOMAS, R.I., will preside.

FEBRUARY 22.—“The Regalia of England.” By CYRIL DAVENPORT.

MARCH 8.—“The Making of a Stained Glass Window.” By LEWIS FOREMAN DAY.

MARCH 29.—“English Art in Illuminated MSS.” By Sir EDWARD MAUNDE THOMPSON, K.C.B.

APRIL 26.—“The Importance of Craftmanship.” By Sir WILLIAM BLAKE RICHMOND, R.A., K.C.B.

MAY 17.—“Practical Points in Italian Majolica Painting.” By WILLIAM BURTON, F.C.S.

CANTOR LECTURES.

The following courses of Cantor lectures will be delivered on Monday evenings, at Eight o'clock:—

CYRIL DAVENPORT, “Decorative Book-binding.” Three Lectures.

LECTURE I.—JANUARY 24.—The beginnings of bookbinding—Assyrian clay tablets in their cases—Egyptian papyrus rolls—Vellum rolls—Roman diptychs—Mediaeval bindings in carved ivory, and metal covers with gems and enamels—Decorative bindings in Europe and the East up to and including the 15th century.

LECTURE II.—JANUARY 31.—Decorative book-binding in Continental Europe, chiefly Italy, France, and Germany, from the 16th to the 18th centuries inclusive, with some notice of Oriental bindings.

LECTURE III.—FEBRUARY 7.—Decorative book-binding in England from the 16th to the 18th century—Gold and enamelled bindings made for Henry VIII. and Queen Elizabeth—Bindings embroidered on

velvet of the Tudor period, and on satin during the 17th century—Gold tooled work by Thomas Berthelet in the 16th century, by Samuel Mearne in the 17th century, and by Roger Payne in the 18th century, and the influence of these great binders upon the art.

HUGH STANNUS, “The Principles of Design in Form.” Four Lectures.

February 14, 21, 28, March 7.

PROF. W. NOEL HARTLEY, F.R.S., “The Thermo-Chemistry of the Bessemer Process.” Three Lectures.

March 14, 21, 28.

DR. D. MORRIS, C.M.G., “India Rubber.” Two Lectures.

April 18, 25.

PROF. CARUS WILSON, “Electric Traction.” Four Lectures.

May 2, 9, 16, 23.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JAN. 3.—Chemical Industry (London Section), Burlington-house, W., 8 p.m. 1. Prof. H. R. Procter and Dr. J. G. Parker, “Standard Methods of Tanning Analysis as adopted by the International Association of Leather Trades Chemists, with remarks thereon.” 2. Dr. J. G. Parker, “Extraction of Tanning Materials at various temperatures.” 3. Messrs. J. H. Coste and E. J. Parry, “Neatsfoot Oil.”

Victoria Institute, 8, Adelphi-terrace, W.C., 4½ p.m.

Rev. John Tuckwell, “Ancient Civilisations.”

London Institution, Finsbury-circus, E.C., 4 p.m. (Juvenile Lecture.) Mr. F. Enock, “Insects at Meals.” (Lecture III.)

TUESDAY, JAN. 4.—Royal Institution, Albemarle-street, W., 3 p.m. (Juvenile Lecture.) Prof. Oliver Lodge, “The Principles of the Electric Telegraph.” (Lecture IV.)

Pathological, 20, Hanover-square, W., 8½ p.m.

WEDNESDAY, JAN. 5.—SOCIETY OF ARTS, John-street, Adelphi, W.C., 7 p.m. (Juvenile Lecture.) Prof. Ramsay, “Fire.” (Lecture I.)

Geological, Burlington-house, W., 8 p.m. 1. Mr. A. Vaughan Jennings, “The Structure of the Davos Valley.” 2. Mr. C. Fox-Strangways, “Sections along the Lancashire, Derbyshire, and East Coast Railway, between Lincoln and Chesterfield.”

THURSDAY, JAN. 6.—Royal Institution, Albemarle-street, W., 3 p.m. (Juvenile Lecture.) Prof. Oliver Lodge, “The Principles of the Electric Telegraph.” (Lecture V.)

FRIDAY, JAN. 7.—Geologists' Association, University College, W.C., 8 p.m. Mr. L. L. Belinfante, “A Brief Account of the Excursions in the Urals, down the Volga, in the Caucasus, &c., made in connection with the International Geological Congress held in Russia, August-September, 1897.”

Quekett Microscopical Club, 20 Hanover-square, W.C., 8 p.m.

SATURDAY, JAN. 8.—Botanic, Inner Circle, Regent's-park, N.W., 3¼ p.m.

Journal of the Society of Arts.

No. 2,355. VOL. XLVI.

FRIDAY, JANUARY 7, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.**JUVENILE LECTURES.**

On Wednesday evening, 5th inst., Professor WILLIAM RAMSAY, Ph.D., F.R.S., delivered the first lecture of his course, addressed to a juvenile audience on "Fire." After alluding to the views of the ancients respecting the supposed four elements, and the belief in the substantial entity of fire, which some races have worshipped, and referring to the old chemical theory of phlogiston, not finally abandoned until the researches of Lavoisier on combustion were universally accepted, he illustrated the principles of combustion, by a series of experiments. He burnt a diamond, thus proving that the diamond and carbon were the same substance, because the products of combustion were the same, and carbonic acid was obtained from both; the diamond, in fact, was crystallised carbon. He burnt steel wire in oxygen, and showed how, by striking iron pyrites with steel, sparks were obtained just as with flint and steel. He then experimented on flames, and explained why blowing a fire improved the flame, and why blowing a candle flame extinguished it. He showed how easy it was to blow out a candle, less easy to blow out gas, and most difficult to blow out the hydrogen flame.

The lecturer then answered, the question "What is a flame?" It is hollow, and has an outside and an inside, which can be made to part company. He proved how much cooler the inside of the flame is than the outside by thrusting a lucifer match, and a spoon with gunpowder into the centre, the explosion of each not taking place for some seconds. He then showed how the incandescent gas light was obtained by the use of a mantle soaked in a solution of yttrium.

Professor Ramsay having dealt in this lecture with combustion, will treat of some other kind of fire in his second lecture, to be delivered on Wednesday evening next, 12th inst.

Proceedings of the Society.**CANTOR LECTURES.****GUTTA PERCHA.**

BY DR. EUGENE F. A. OBACH,
F.I.C., F.C.S., M.I.E.E.

Lecture II.—Delivered December 6, 1897.

THE CLEANING PROCESSES.—Mechanical cleaning process—Loss during mechanical cleaning—Chemical washing process—Chemical hardening process—Extraction from raw material and from leaves by means of solvents—Advantages and disadvantages of the different processes—Natural substitutes for gutta percha, including balata.

In the previous lecture, I mentioned that the first specimens of gutta percha brought to Europe from which any practically useful results accrued, were those sent to the Society of Arts by Dr. William Montgomerie in 1843, and I should now like to show you on the screen the portrait of this gentleman, reproduced from a photograph¹ belonging to his daughter, Miss Edith Montgomerie, who has kindly lent it me for that purpose. Dr. Montgomerie was born at Irvine, Ayrshire, N.B., in 1797, and therefore just 100 years ago; he died at Barrackpore, near Calcutta, March 22nd, 1856.

MECHANICAL CLEANING PROCESS.

To-night we have to consider the various cleaning processes to which the raw gutta percha is subjected after reaching the premises of the manufacturer, and I will begin with the *mechanical cleaning process*.

The first patent specification in which reference is made to the cleaning of gutta percha, is one by Richard Archibald Brooman (No. 10,550 O.L.), dated March 11, 1845, and entitled as follows, viz.:—*Employing Gutta Percha in the Manufacture of Artificial Fuels, Mastics, and Cements*. The invention is described as having been communicated from abroad, but it appears that the true inventor was no other than Charles Hancock, the patentee of several other inventions relating to gutta percha, as I have been informed by his son, Mr. Walter Hancock.

Brooman describes apparatuses for washing and kneading gutta percha, and illustrates them by diagrams which are reproduced here. Diagram Fig. 19 shows the *washing machine* (1); it consists of two smooth rollers, C¹ and C², rotated in opposite directions, and with different speeds by means of the toothed

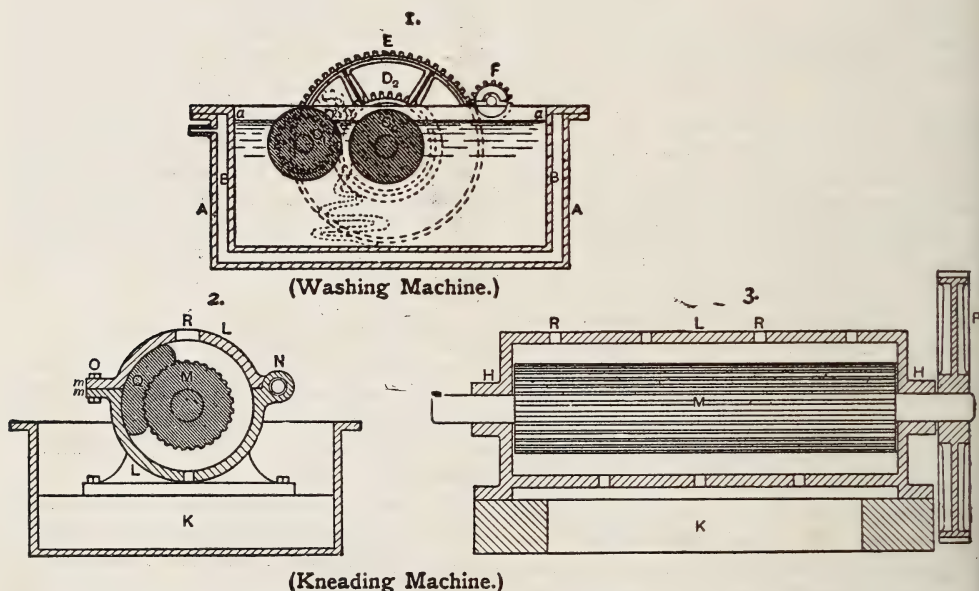
¹ Will be printed in the *Appendix*.

wheels, D^1 and D^2 . The rollers are almost completely immersed in water in a tank provided with a steam-jacket for heating the water. The gutta percha is put between the rollers and passed through them several times in succession, until it appears sufficiently clean. Fig. 19 also shows the *kneading machine* (2 and 3) in section. It consists of a grooved roller, M, rotating concentrically in an iron shell surrounded by hot water. The shell is provided with a hinged lid, L, which can be kept closed by bolts, O. The softened charge of gutta percha, Q, is taken round and round by the roller, M.

The next patent, referring to the cleansing of gutta percha, is one taken out by Charles

Application of Gutta Percha. Here a machine is described and illustrated for slicing the raw material, and another for still further disintegrating it. Diagram Fig. 20, which is a reproduction of the drawing in the patent specification (1, 2, and 2a) represents the *slicing machine*. B is a heavy iron disc with three slots, each provided with a knife resembling the blade of a plane or spokeshave. The disc is rotated by means of a shaft, B^2 , and the lumps of raw gutta percha are thrown into a hopper, D, whence they drop against the disc and are cut into slices by the knives on passing. The other arrangement, which may be termed a *breaking and mincing machine*, is shown at (3); it is a rather complicated one, its

FIG. 19.



R. A. BROOMAN'S PATENT OF MARCH 11, 1845.

Hancock in his own name (No. 11,032 O.L.), on January 12th, 1846, under the title: *Manufacture and Application of Gutta Percha*. In this specification a method is proposed for purifying gutta percha by straining it in the hot and plastic state through wire gauze under pressure; but mention is here already made of cleansing the raw material by dissolving it in oil of turpentine or other suitable solvent, and filtering the solution through wire gauze, flannel, or other fabric, afterwards distilling off the solvent to recover the gutta percha.

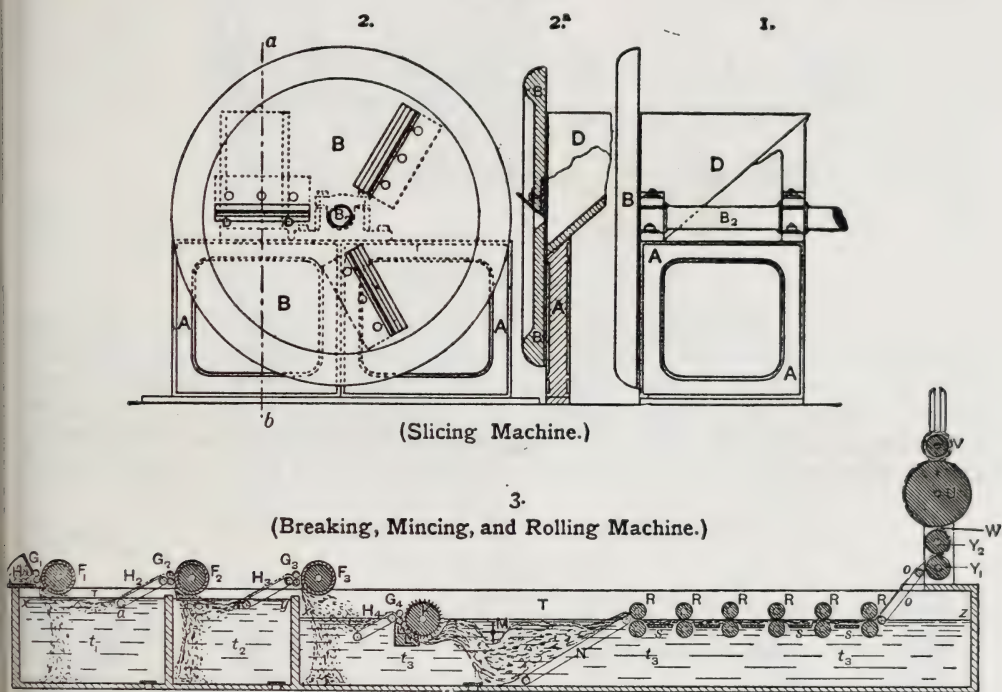
The third patent (No. 11,575 O.L.) of Feb. 10th, 1847, was likewise taken out by Charles Hancock, under the title: *Preparation and*

object being to tear up the material into shreds, in order to expose the dirt enclosed therein. The slices from the first machine are first softened in hot water, and then thrown into the hopper, H, on the left side of the long trough, T. This trough is divided into three compartments, t^1 , t^2 and t^3 , containing cold water. The soft gutta percha in the hopper is taken up by the feeding rollers, G^1 , and forced against the rapidly rotating breaker, F^1 , provided with a number of serrated blades on its periphery. The disintegrated material falls into the water, the heavy dirt sinking to the bottom, whilst the lighter gutta percha floats and is taken up by the endless web, H^2 , which carries it to the next pair of feeding rollers, G^2 , and they in

their turn force it against the second breaker, F^2 . This operation is repeated once more at F^3 . The material then passes to the mincer, K , where it is cut up by means of rotating knives, passing close to fixed ones in the block, L . The agitator, M , stirs it up in the water and throws the lighter gutta percha towards the endless band, N , which lifts it up to the first pair of rollers, R , which, with the succeeding rollers, compress the material into a sheet; the latter is then taken up by the endless web, O , and passed through the two large rollers, Y^1 and Y^2 , round the wooden drum, U , and then to the taking-up roller, V . The apparatus,

softened in hot water, or the lumps are directly placed in hot water and the soft material transferred to the washing machine. There it is washed with plenty of hot water for a longer or shorter time, according to circumstances, and then passed through a strainer. After straining, it is mostly washed once more, then put into the kneading or masticating machine, to consolidate it and remove the mechanically enclosed water, and finally it goes to the rolling mill, where it is made into sheets of various thicknesses. I will now show you these different machines on the screen.

FIG. 20.



CHARLES HANCOCK'S PATENT OF FEBRUARY 10, 1847.

in a simplified form, is still in use at some works under the name of *ticker*, and I have here some gutta percha in "flocks," which have evidently been produced in some such way. I also have some very thin "strippings," obtained by passing the material between closely-set rollers, and which are in a very favourable condition for further treatment.

Those were the early machines used for cleansing gutta percha; at the present day, various systems are employed by different manufacturers, but generally speaking it may be said, that the raw gutta percha is either first cut up in a slicing machine and then

The *slicing machine* or chopper (Fig. 21), at present in use, is still pretty much the same as that proposed by Hancock 50 years ago, except that it is provided with a greater number of fluted and serrated knives, instead of only three plain ones. The enlarged section shows how the knives are fixed in the slots of the heavy iron disc. The blocks of raw gutta percha are packed into the trough, shown in the illustration, and are then forced against the rotating disc by the piston, which is advanced by a rack and pinion. The slices, cut off by the knives, fall into the rectangular box shown in outline in the drawing. I have here a basket filled

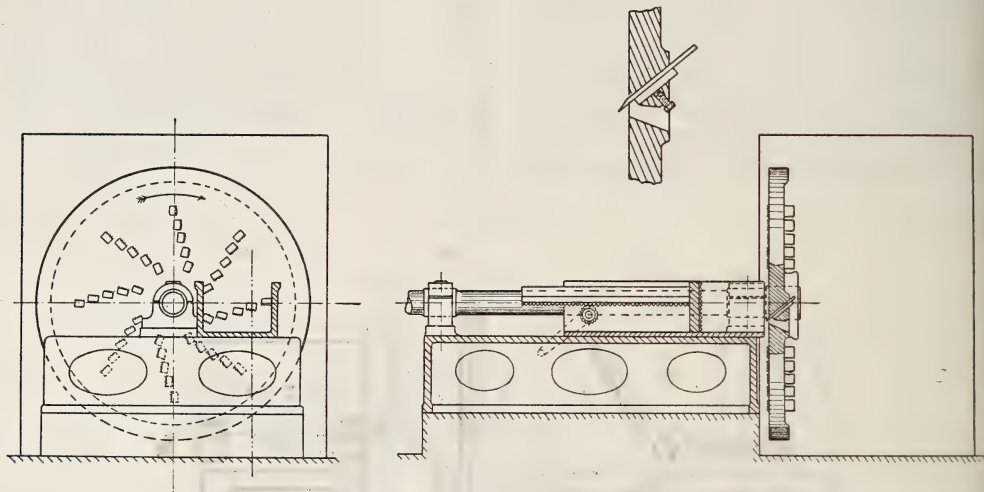
with this sliced material, and I purposely selected a gutta percha containing a large amount of wood and bark.

The *washing machine* (Fig. 22), consists of an iron roller of star-shaped section, enclosed in a cylindrical shell provided with one or two

from time to time withdrawn through one of the little doors shown in the illustration. The washing process is carried on until samples taken from the charge appear sufficiently clean.

The *straining machine* is shown in Fig. 23. The gutta percha, in the plastic state as it

FIG. 21.

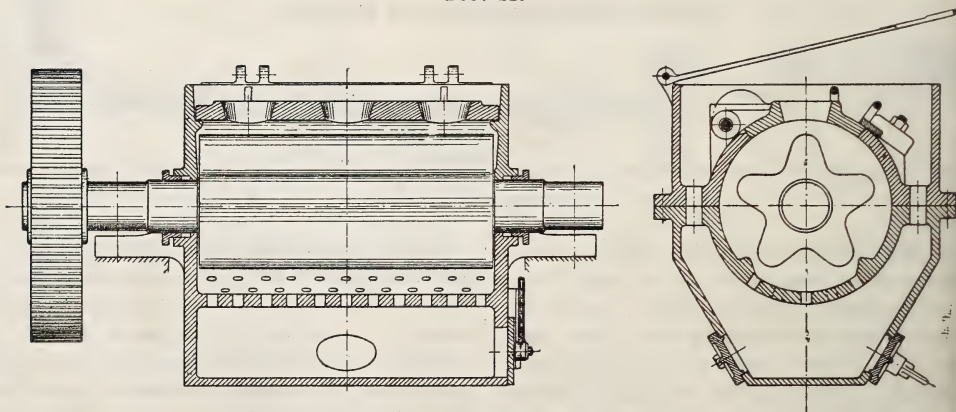


SLICING MACHINE OR CHOPPER.

projections or ribs, against which the gutta percha is forced in going round. The difference between the modern washer and that proposed in Brooman's patent specification is, that it has only the one fluted roller, whereas the old machine had two smooth ones, working against

comes from the washer, is put into a strong iron cylinder with a perforated bottom, on which a number of discs of fine wire gauze have previously been placed. The piston is then driven down by means of the hydraulic cylinder and force pump, and the soft gutta

FIG. 22.



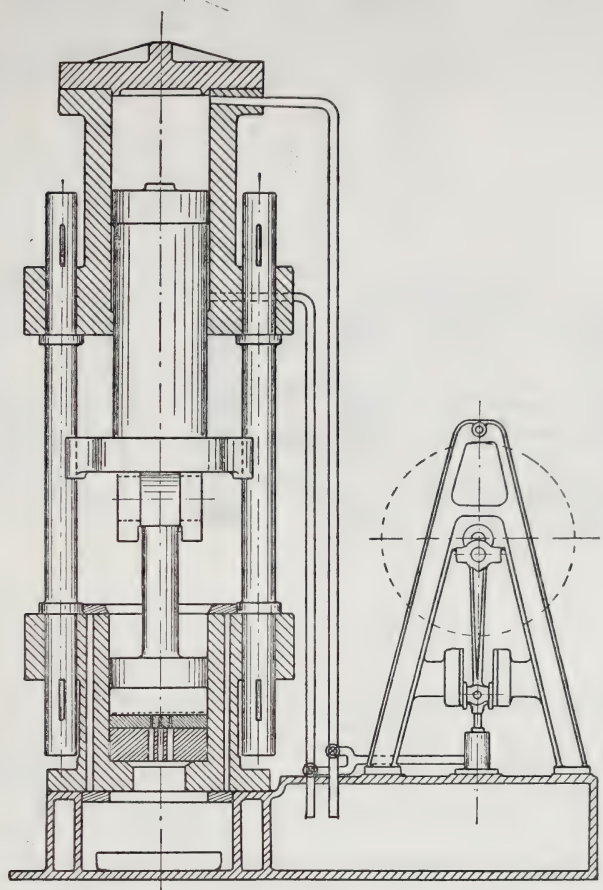
WASHING MACHINE.

each other. As shown in Fig. 22, the cylindrical shell is enclosed in a large iron case, which is filled with water, heated by means of direct steam. The dirt which is washed off, falls through the lower part of the cylindrical shell into the outer case, whence it is

percha squeezed through the fine meshes of the gauze into a collecting tray underneath. Considerable pressure is required for the operation, varying between 14 and 18 cwt per square inch, according to the stiffness of the material.

The *kneading machine* or "masticator" is illustrated in Fig. 24. In general appearance catches. The gutta percha is kept hot during mastication, and the water escapes in the form of

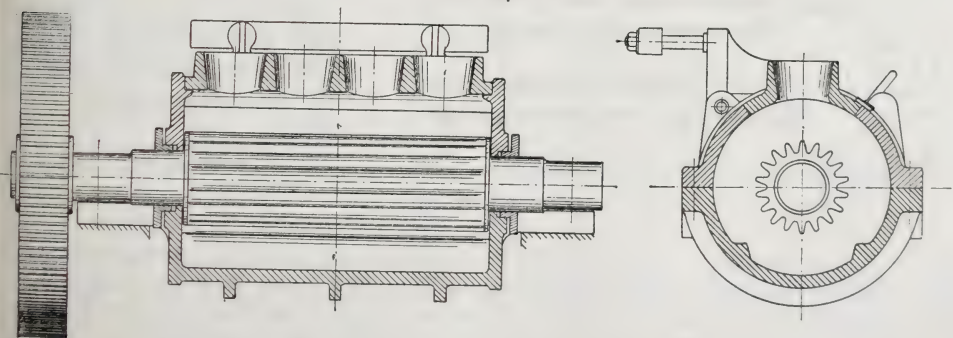
FIG. 23.



STRAINING MACHINE.

It resembles the washer, but the roller has a smaller diameter, and the flutings are more steam through the large openings at the top. The washers usually hold about $\frac{3}{4}$ cwt., the

FIG. 24.



KNEADING MACHINE (MASTICATOR).

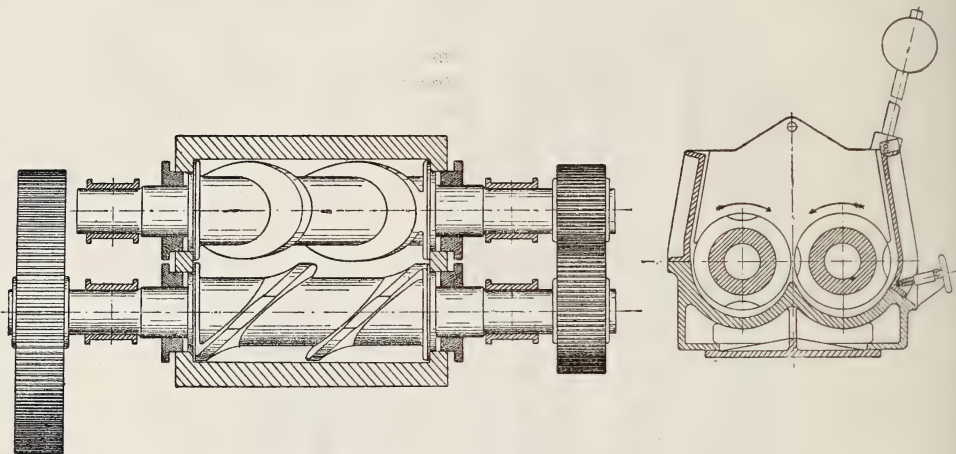
numerous and not so deep. The hinged lid can be kept down by means of a bar and suitable masticators 1 cwt., and the strainers $\frac{1}{2}$ cwt. of gutta percha.

The *mixing machine* (Fig. 25) was introduced by my friend, Mr. Paul Pfeleiderer, about 20 years ago, under the name "Universal Kneading and Mixing Machine." It is largely used in the chemical industry, the india-rubber and linoleum manufacture, &c., and it consists of two iron rollers, provided with

between $\frac{1}{8}$ and $\frac{1}{4}$ inch, and it is then cut up into lengths of 5 or 6 feet for stacking in the cellar until required for use.

The *rolling mill* is shown in Fig. 26. The soft gutta percha from the kneading machine is laid on a table, in front of a pair of parallel rollers; it is then pushed up against the rollers

FIG. 25.



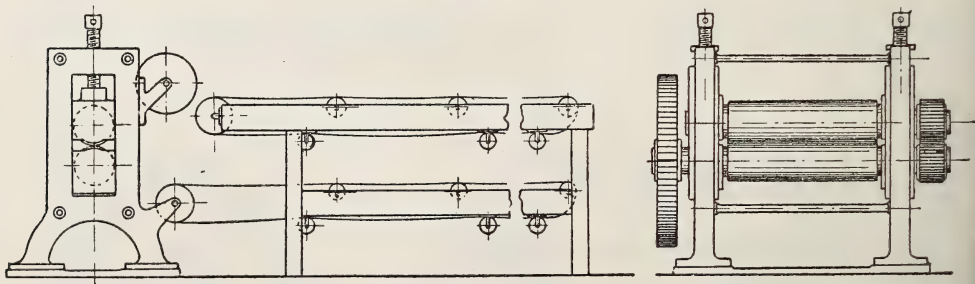
"UNIVERSAL" MIXING MACHINE.

peculiarly shaped blades, which work against one another, as shown by the arrows. The machine is used for intimately mixing the various sorts of gutta percha, in order to obtain a material of any requisite properties. It can also be used for blending gutta percha with pigments or other ingredients for special

and squeezed through in the form of a sheet, which is taken up by an endless band, on which it travels some distance to and fro until it is sufficiently cool and hard to be cut into the shorter lengths for storing.

I should now like to draw your attention for a moment to some of the exhibits. I have

FIG. 26.



ROLLING MILL.

purposes. I need hardly say that the rollers can be heated by means of steam, but heat is also developed by the kneading process itself, and one has to be careful not to over-heat the material and thereby injure it.

After mastication, the gutta percha is rolled out into a sheet of suitable thickness, usually

already pointed out to you the basket with the slices as they come from the chopper. By the side of it is another one, containing the original blocks of the same material. On that table you see a full-sized charge ready for the washing machine, still containing most of the dirt embedded in it; next to it there is a

charge which looks much cleaner, as it has been in the washer for some time; and this roll here is quite clean, having successively passed through the washer, strainer and masticator. A number of clean sheets of different brands of gutta percha, as they come from the rolling mill, are also exhibited for your inspection.

Here is a small working model of three washers in a hot-water tank, and a little masticator, similar to those which I described to you. I am going to drive these miniature machines by means of an electric motor, and we shall then actually carry out the washing and masticating processes in your presence.

We have determined the percentage of water and dirt in various kinds of gutta percha at different stages of the mechanical cleaning process, and the average result obtained with several materials, is shown in Diagram Fig. 27.

Some of it, viz., about 3 per cent., is removed during the preparation for the washer; but most of it disappears during the first washing operation. The straining, on the other hand, hardly affects the percentage of dirt, and this operation is carried out more for safety's sake, to prevent any larger pieces of dirt, especially of a fibrous kind, being left in the cleaned material. The second washing process following the straining, is again effective, as it removes nearly another half per cent. The remaining 1.8 per cent. of impurities would be admissible for most practical applications; but for special purposes, it may have to be still further reduced.

The result of an experiment on straining is given in Table VI. The object of this experiment was to determine the amount and character of the impurities retained by the gauze diaphragm of the strainer from a definite quantity

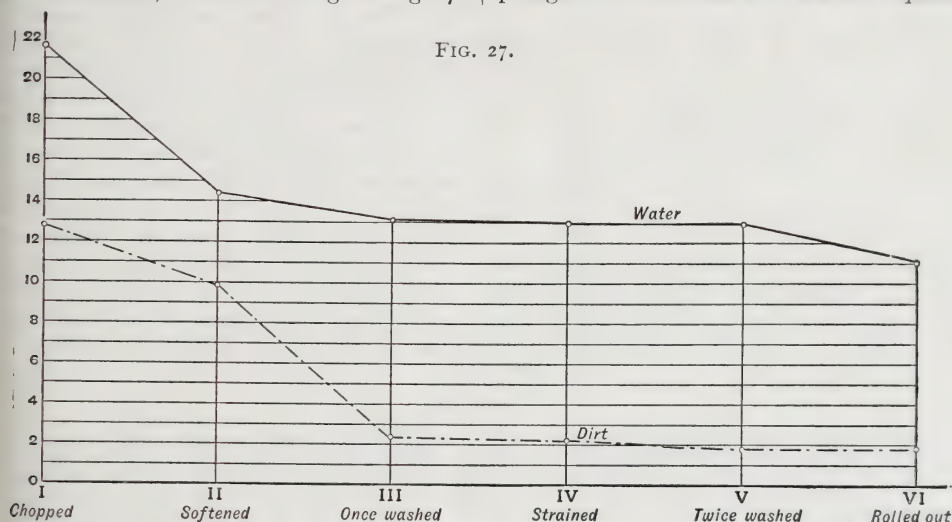


FIG. 27.

WATER AND DIRT-DRIVING MECHANICAL CLEANING PROCESS.

Let us first consider the *water*. The material as it comes from the chopper, contains 21.5 per cent., this is reduced to 14.4 per cent. during the softening and preliminary preparation for the washer; but curiously enough, the water actually diminishes in the washer to about 13 per cent., and then remains constant until it reaches the rolling mill, when it loses another 2 per cent. by evaporation. This seemingly paradoxical result is to be ascribed to two causes, viz.: the consolidation of the material in the washer, by pressure, and the removal of the dirt, which in account of its porous nature, encloses a large amount of water.

As regards the *dirt*, we observe that the chopped material encloses 12.8 per cent.

of washed gutta percha. The diaphragm consisted of three superimposed discs of wire gauze, the upper one being of iron wire, and having 68 meshes to the linear inch; the middle and lower discs were of brass wire, and had 100 meshes to the inch. Twelve charges of $\frac{1}{2}$ cwt. each were forced successively through the strainer, after which the diaphragm was removed and the adhering gutta percha dissolved by carbon disulphide. The discs were then taken apart, the dirt carefully scraped from each, separated into "fibrous," "granular," and "magnetic," and weighed. Part of the magnetic substances was probably present in the raw gutta percha, but some of it has no doubt got into the material by abrasion from

the iron machinery with which it had come into contact during the preceding cleaning process. The figures show that in each case the coarse 68-mesh strainer on the top contained by far the largest amount of impurities, and that a little dirt which passed the intermediate 100-mesh gauze was removed by the next gauze disc of equal fineness. Altogether 2·179 grammes of

TABLE VI.—STRAINING EXPERIMENT.
(6 cwts. passed through triple strainer.)

Description of Impurities.	Weight of impurities found on strainers.			
	Top strainer. (68-mesh.)	Intermed. strainer. (100-mesh.)	Bottom strainer. (100-mesh.)	All three strainers.
	gr.	gr.	gr.	gr.
Fibrous	0·722	0·425	0·062	1·209
Granular ...	0·433	0·221	0·051	0·705
Magnetic ..	0·170	0·081	0·014	0·265
Total ...	1·325	0·727	0·127	2·179

	gr.
Impurities retained on strainers.....	2·179
„ removed in G. P.	0·430
Total.....	2·609

Gutta Percha retained on strainers, 160 gr.

dirt were found on the three gauze discs, the fibrous constituent thereof amounting to over one half. To this has to be added the dirt found in the gutta percha extracted with the

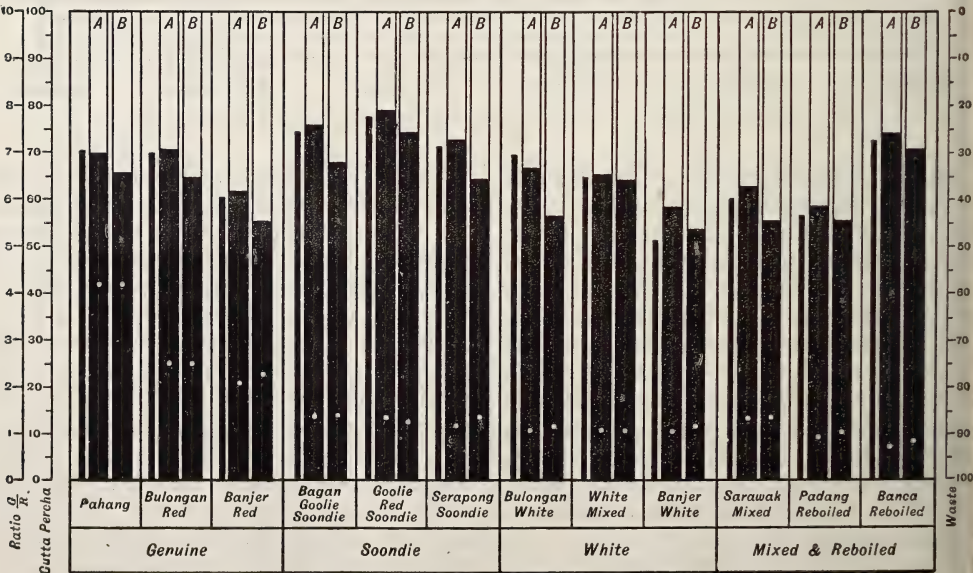
solvent, viz. 0·43 g., making a total of 2·609 g. The quantity of gutta percha from which this dirt had been abstracted by straining being 6 cwts., it is easily seen that the percentage of dirt cannot have been perceptibly affected.

LOSS DURING MECHANICAL CLEANING.

The loss or “waste” which raw gutta percha sustains during cleaning and drying is sometimes a very heavy one, and occasionally reaches fully 50 per cent.

Diagram Fig. 28 represents the percentage yield of clean gutta percha obtained on cleaning a number of raw materials of each of the 12 different “brands,” mentioned in my first lecture. For direct comparison I also give in the Diagram the corresponding percentages of gutta percha proper, calculated from the analyses of small samples of the same raw materials which were eventually cleaned in the works, the column marked (A) showing the results of the laboratory, and that marked (B) those of the works. The thinner black line to the left of (A) shows the percentage of gutta percha proper for each particular brand obtained from the analyses of a much greater number of individual lots, and is taken from Diagram Fig. 14 of the first lecture. A comparison of the length of the black column (A) with that of the thin line by its side shows therefore to what extent the lots, for which both analytical and practical data had been available, really represent the particular “brand” of gutta percha.

FIG. 28.



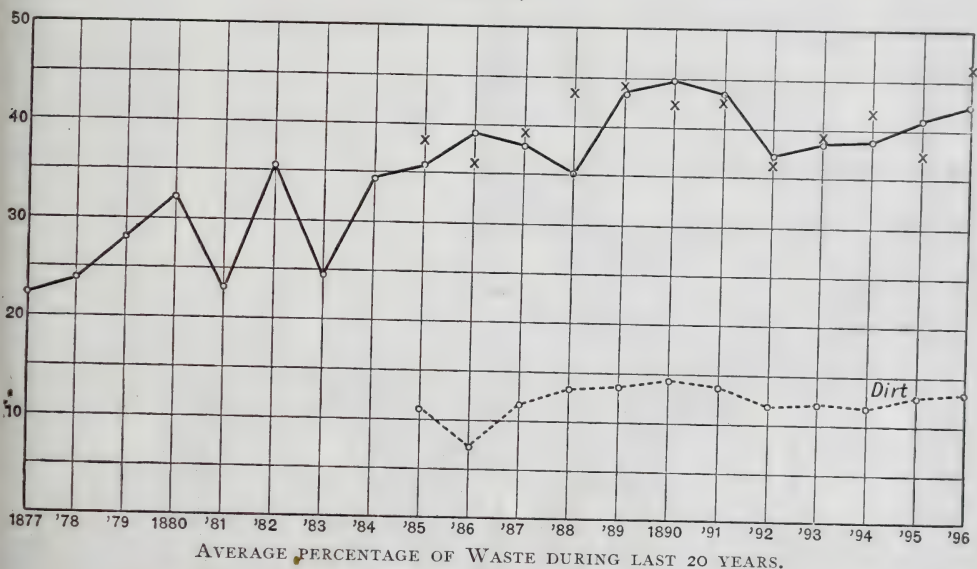
GUTTA PERCHA FOUND BY ANALYSIS AND ON ACTUAL CLEANING.

According to the Diagram the percentage of gutta percha actually obtained in the works is in almost every instance lower than that determined by analysis, *i.e.*: column (B) is invariably a little shorter than column (A). The reason of this discrepancy is not far to seek. When the small sample of raw gutta percha is taken for analysis, it is almost impossible to prevent loss of moisture and dirt; moreover, the larger enclosures, such as stones, pieces of bark, &c., are not represented, and therefore evade analysis. An allowance for these omissions has therefore to be made in estimating the actual yield of clean gutta percha from the analysis of its raw material, which depends on the particular class of material under consideration; but may be taken on the average as 9 per cent. of the gutta percha proper found by analysis, or roughly speaking, 6 per cent. of the original raw material.

the denser clean material; the resin is therefore more completely removed from the former than from the latter. The slightly higher position of the dot indicating the ratio $\frac{g}{r}$ in column (B) as compared with that in column (A) is clearly indicated in the Diagram. The exact figures will be given in a Table in the Appendix.

Diagram Fig. 29 represents the average percentage loss obtained on cleaning large quantities of raw gutta percha of various kinds for each of the last 20 years. The results are significant, showing that this loss gradually increased from 22.5 per cent. in 1877 to 32.2 per cent. in 1880, 35.6 per cent. in 1885 and 44.6 per cent. in 1890; the mean loss during the entire period being about 33½ per cent. This Diagram also gives the average percentage of dirt found in the same lots of raw gutta percha by analysis for each year from 1885 to 1896,

FIG. 29.



As before, the ratio $\frac{\text{gutta}}{\text{resin}}$ is represented in the Diagram by the height of the white dot in the corresponding black column, and it is interesting to observe that this ratio is on the whole more favourable in the case of cleaned gutta percha than in that of raw materials. The reason is that when the resin is extracted from the raw material during analysis, a little resinous matter is also abstracted from the wood and bark, whereas this is not the case with cleaned gutta percha. Another reason is that raw gutta percha is more porous and consequently more pervious to the solvents than

and the total waste thus obtained and corrected as explained before.¹ A Table giving the actual figures will also be published in the Appendix. To a certain extent, the percentage of waste goes hand in hand with the quantity of raw gutta percha imported into the United Kingdom, as a comparison of the respective curves shows; but roughly speaking, one may say, that at the present time it is almost twice as great as it was 20 years ago.

You may have noticed the comparatively fine dirt, chiefly wood and bark, contained in most

¹ Shown on the Diagram by crosses.

of the raw materials which I showed you on the last occasion, and to-night; but frequently larger pieces of various foreign substances are fraudulently hidden in the blocks. One may, I think, term this big lump of quartz a rather "coarse impurity," as it weighs over 3 lbs. Notice also these large quartz crystals, and those pieces of metal. I have here quite a collection of such "rarities," which have been found embedded in blocks of raw gutta

shown in Fig. 30 explain themselves; to some of them, however, I shall recur presently. If stones or metal are enclosed in the blocks, the knives of the chopper will be seriously injured, and if they should get into one of the washing machines the damage may be considerable, unless frictional driving is resorted to, which is very advisable. Here, for instance, is a small iron stamp (Fig. 30, No. 2), such as is used for marking block tin, which was found

FIG. 30.



FOREIGN BODIES FOUND IN RAW GUTTA PERCHA.

percha, and I thought it might be worth while to photograph them for reproduction in the *Journal* (Fig. 30). No. 1 shows three iron axes, such as the natives use for felling trees, and with which we have already become acquainted in the previous lecture under the name of "billions." No. 3 represents pieces of wood, one of them showing the marks of the serrated chopper knives with which it came into collision. Most of the other articles

only a few months ago, when it was already too late, that is, after it had got into one of the washers and damaged it to the extent of over £60.

Last year, shortly after the discovery of the X-rays by Prof. Röntgen, I also experimented with these rays, and it occurred to me to test the transparency of gutta percha to them. I found it exceedingly transparent, and this induced me to have a number of blocks of

raw gutta percha examined with the *cryptoscope* to see whether they enclosed any stones or other heavy materials. Out of 450 pieces of "White Bulongan," a material which appeared particularly likely to give some results, we found seven containing stones. We also examined 300 pieces of "Mixed Sarawak," but failed to detect any; however, in another lot of the same kind of material we found one piece containing a stone, and I have photographed it by means of the X-rays and will now show you the result on the screen. This stone nobody has seen since it was first put into the block of gutta percha; we shall now cut the block open and expose the stone—here it is, and you observe it corresponds exactly with the X-ray photogram.⁽¹⁾

CHEMICAL WASHING PROCESS.

We must now briefly consider the chemical washing process. Charles Hancock, in his patent specification (No. 11,208 O.L.), of May 15th, 1846, proposed to steep the raw gutta percha, after it had been cut up into small pieces, in a solution of caustic alkali or chloride of lime to neutralise the acidity and remove any unpleasant odour. If a hot solution of caustic alkali is used in the washer in place of water, the material becomes much cleaner and attains a lighter colour. I have here two specimens of the same gutta percha; the one, which I hold in my left hand has been washed with water in the usual way; but the other, in my right hand, has had an additional washing with a weak solution of sodic hydrate, and you observe the notable difference in colour. I have made numerous experiments on the chemical washing of gutta percha, but will content myself with describing the result of one of them. A particular raw gutta percha belonging to the class of materials which do not readily part with their impurities, was twice washed with water, then rolled out into sheet and analysed. It was found to contain 12.7 per cent. of water and 1.7 per cent. of dirt. Another portion of the same raw material was washed with a 5 per cent. solution of sodic hydrate, then with water, rolled out into sheet, and analysed as before. The analysis now gave only 5.2 per cent. of water and 0.4 per cent. of dirt. This experiment

clearly shows that the treatment with the alkaline solution not only reduced the percentage of dirt to less than one-fourth of the original amount, but it also affected the capacity for retaining mechanically enclosed water. The treatment of gutta percha with hot alkaline solutions, or lyes, or in fact with any other chemicals, requires great care and judgment, and the subsequent washing with water must be done very thoroughly; otherwise the material may be detrimentally affected and perish after a comparatively short time.

CHEMICAL HARDENING PROCESS.

I will now describe the process for hardening gutta percha which I introduced about 16 years ago. As you will remember, I pointed out in the last lecture that the really valuable constituent of gutta percha is the gutta, and the more a material contains of it the better it is, provided the gutta itself is of good description. Now, for certain purposes, it is advantageous to improve the hardness and other mechanical properties of gutta percha, and this can be done by extracting the resin with a suitable solvent which leaves the gutta itself intact.

I have here some cubes of raw gutta percha immersed in different liquids, and you observe that they have retained their original form and sharpness of outline; but if you were to examine the liquids, you would find that every one of them was charged with the resinous substances originally contained in the gutta percha. One of the liquids is ether, the other a saturated solution of carbon disulphide in alcohol, and the third light petroleum spirit. It is the last named liquid, variously known as lythene, rigolene, gasolene, &c., and having a specific gravity of about 0.65 to 0.67, which I use for my hardening processes.

Fig. 31 gives a schematic view of the various apparatuses employed for that purpose. In those on the left, the different preparatory processes are carried out and in the others on the right, the actual treatment takes place.

The raw gutta percha is first chopped, then thrown through a screen, *S*, on to a long drying platform, *P*₁, gently heated from below by a system of steam pipes. The material is shovelled along, and thereby continuously turned over, until it reaches the other end of the platform, where it is thrown on to a second and lower platform, *P*₂, and there similarly moved along to the other end. By this time the gutta percha should have become fairly dry; out in order to complete the drying, it is now

(1) The block after having been cut open was photographed in the ordinary way, and is shown in Fig. 30, No. 4, one of the rolls of White Bulongan, containing a stone, was shown after the lecture with the Röntgen apparatus. Other stones found embedded in blocks on cutting them open, are represented in Nos. 7 and 8.

thrown into the hopper, h_1 , of a long iron drum, D, provided with narrow shelves, which take it round for a certain distance, when the drum is rotated and at the same time move it along since the axis of rotation is slightly inclined towards the other end. A gentle current of warm air, passed through the drum in the opposite direction, carries away the moisture given off by the material, and thus accelerates the drying. After leaving the drying drum, the pieces enter the sifting drum, S, the finer particles falling through the openings, and the coarser pieces moving along inside, until they are discharged at the other end of the drum, where they fall into an upright iron vessel, V, provided with a suitable distributing arrangement. The finer material, on the other hand, drops on to an endless band, t , and is carried along by it to a bin, B. The coarse and fine materials are thus effectually separated. The galvanised-iron tank, a , provided with a hinged lid and a movable plate in front, can be carried about by a travelling overhead crane. The tank is filled first with coarse pieces from the vessel, V, then with finer stuff from the bin, B, and finally again with coarse pieces, the depth of each layer depending upon the particular material to be treated. This is done to facilitate the percolation of the solvent during the extraction process. The bottom of the tank, a , is perforated and covered with wire gauze. After charging the tank as just described, it is carried over to the other side and deposited in one of the larger tanks, A, B, or C, of which there may be any number connected up *en cascade* by a system of pipes. These tanks, after having each received one of the smaller ones, a , filled with raw gutta percha, are worked in groups of three, to which number the schematic drawing is confined. Petroleum spirit from a large store-vessel overhead, T_2 , is admitted to the first tank of each group—A, for instance—and flows over into the next tank, B, and from there into the third, C, filling all three in succession. The circulation of the “spirit” is carried on until it is found to be quite clean as it leaves the first tank; this tank is then disconnected from the two others, and a tank with fresh raw material connected to the former No. 3, the second one in its turn now becoming the first, and so on.

The solution which comes from the third tank of a group is pretty thick, containing a large amount of resin. It is run into tank T_3 , and from there in a continuous stream

into a large still, S, provided with a steam coil at the bottom. The contents of the still are heated, the “spirit” distilled off and condensed in a suitable cooling arrangement, C_2 , which delivers it into the main store tank in the cellar, whence it is pumped up again into tank T_2 .

The “spirit” from tank A, is run off into the main tank, T_1 , the material further washed with clean spirit and then allowed to drain, whilst communication still exists with the tank in the cellar. The inner tank, a , is now lifted out and brought to the front of the large masticator, M. It is laid on its side, pushed into the mouth of the masticator, and the contents discharged by withdrawing the side of the tank, which now forms the bottom, the masticator having previously been filled with cold water. After removing the tank, the large swing-door of the masticator is closed, steam is turned on, and the rollers set in motion so as to knead the gutta percha, whilst the solvent is being distilled off. When the distillation ceases, the remaining vapours are blown over into the condenser by means of steam, the masticator is then opened, the gutta percha taken out and washed in the usual way with water, or, if necessary, with an alkaline solution.

The distillation of the resinous solution is carried on until the contents of the still, S, have become very thick, and the solvent, in consequence, distils over only tardily. The supply of fresh solution is then interrupted, the valve between the still and condenser closed, but the heating continued, until a certain pressure has been produced by the vapours, which is then utilised to force the contents of the vessel into another still, situated at a safe distance outside the building, where the heavier parts of the solvent are distilled off by heating directly over a fire. This done, the contents of the still are discharged through a kind of treacle-valve, and run into barrels or other suitable receptacles for further use or sale.

Before leaving this subject, I should like to mention that all the different tanks are mutually connected by means of a system of air pipes, provision being made that flames cannot spread from one to the other in case of fire. The main pipe of this system is finally carried to the vessel V (of which there are two, used alternately), containing coarse pieces of dried raw gutta percha, as already mentioned. The air in passing through the gutta percha before being discharged into the open is thus

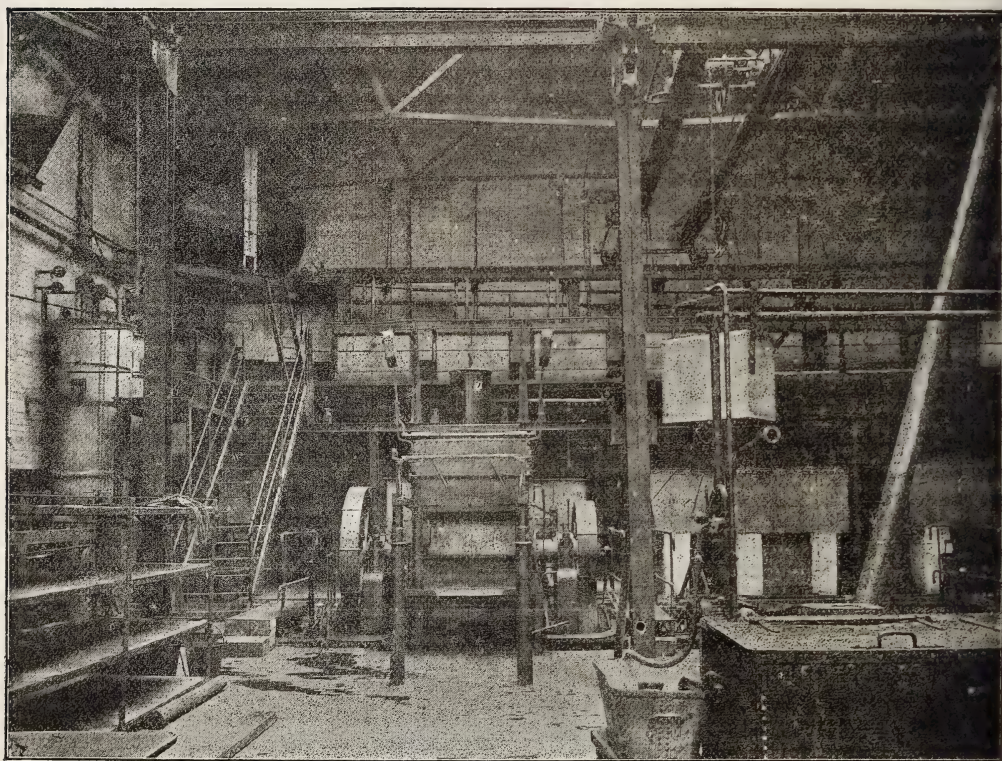
deprived of all vapours, which is very desirable for safety as well as economy.

I will now show you some of the actual machinery employed for this hardening process, on the screen.

Fig. 32 depicts the interior of the works, in which the treatment with petroleum spirit is carried out. You observe the row of rectangular tanks on the elevated platform at the back, the high-level store-tank in the corner on the left, the masticator in front, and the two upright vessels containing coarse

are two portions of raw gutta percha from the same block cut up into small cubical pieces, one portion is still in its original condition, but the other has been treated with petroleum spirit to extract the resin as completely as possible, and was then freed from the solvent in vacuo at a slightly elevated temperature. This large glass vessel, containing water, is being heated on a sand bath, and the water has now reached a temperature slightly above 50° Centigrade. A smaller glass beaker, also containing water, is

FIG. 32.



INTERIOR OF HARDENING WORKS.

pieces of raw gutta percha, and serving as absorption towers for the vapours, just below the store-tank. The second slide shows the masticator on a larger scale, and the third¹ the row of stills used for concentrating the resinous solution by distillation of the solvent.

Before leaving this subject, I should like to demonstrate to you by a simple experiment, the efficiency of the hardening process. Here

immersed into the outer vessel, and its contents therefore have practically the same temperature, or if it should be different, a slightly lower one. I now throw the *original* material into the inner vessel, and the *hardened* one into the outer, and leave them there for a short time, until they have acquired the temperature of the water. I try to squeeze the pieces of treated gutta percha between my fingers; but they resist the pressure as they are still quite hard. I do the same

¹ The second and third views are not reproduced in the *Journal*.

with the original material inside the beaker, and you observe that it is quite soft and plastic. I shall recur to the great difference in the softening temperature of materials, with different percentages of resin, in my next lecture.

EXTRACTION FROM RAW MATERIALS.

Instead of removing the impurities from raw gutta percha by washing it either with water or an alkaline solution, as described in the first part of this lecture, this can also be done by dissolving the gutta percha in a suitable liquid, straining or filtering the solution, and then evaporating the solvent. This method has repeatedly been employed and had, as we have seen, already been suggested by Charles Hancock⁽¹⁾ in 1846. I myself tried this mode of purification on a rather large scale some 20 years ago, using carbon disulphide as the solvent; but I soon abandoned it again, as it was found that the clean gutta percha thus obtained, although apparently of excellent quality, shortly after it had been produced, it nevertheless quickly perished; and this appears to be the fate of most materials obtained by evaporation of a solvent, probably because the molecular structure of the gutta is thereby affected. But there is yet another method of reclaiming a dissolved substance, viz., by precipitation, and this also is frequently employed for gutta percha.

Here is a solution prepared from raw gutta percha by means of carbon disulphide, and you observe that the dirt has settled down at the bottom. Part of the clear solution has been decanted off and the solvent evaporated, the residual gutta percha being pressed into this plate. Another portion of the solution is in this tall test mixer, and I will now add an excess of alcohol and shake it up. You see a whitish precipitate is being formed, which could be separated from the liquid by filtration and made into a plate like the one I just showed you. There would, however, be this difference in the composition of the two plates, that the one obtained by evaporation of the solvent contains all the resin originally present in the raw material, whereas the other, obtained by precipitation, consists, practically, of pure gutta; and this is the case, more or less, with all processes in which precipitation is employed.

EXTRACTION FROM LEAVES.

The present method of obtaining gutta percha from the latex in the bark of the trunk, after felling the tree, is no doubt a very crude and wasteful one, and, consequently, any feasible suggestion to remedy this state of affairs deserves our most serious consideration. It is now about six years since a proposal was made to extract gutta percha from the removable parts of the tree, such as small branches, twigs, and leaves, which can be plucked without injury to the tree, instead of from the trunk. In this way, besides saving the life of these valuable trees, other advantages would accrue, one of them being that adulterations could less easily be practiced, the leaves of the gutta tree being easily recognisable, and not very difficult to distinguish from those of other trees, even of kindred species.

This frame encloses a small branch and several exceptionally fine leaves of *Palaquium* (*Dichopsis*) *gutta* (Fig. 33), and you observe the characteristic projection or beak at the upper end of the leaves, and their pronounced reddish-brown tinge and silky lustre. If you were to examine the leaves more closely, you would see that each of them has at least twenty-two lateral veins, branching out on both sides of the mid-rib, mostly at an angle of about 70° or 80°. Compare these with the leaves of the two branches in the other frame (Fig. 34) which belong to trees yielding an inferior kind of gutta percha, viz., *Dichopsis polyantha* and *Dichopsis pustulata*, and you cannot fail to be struck by the great difference between them, not only with regard to the size and shape, but also in the number and prominence of the secondary veins which here are only 12 to 15 on each side of the mid-rib, instead of 22 and more. Some time ago I examined numerous specimens of *sapotaceous* plants in the Berlin Herbarium, measuring the dimensions of the leaves and counting the lateral veins, and I arrived at the conclusion that none of them could be confounded with those of the true gutta trees. I may add that in the case of the two inferior species of *Dichopsis*, which I just showed you, the angle between the lateral veins and the mid-rib is also a more acute one, i.e., generally less than 70°.

If a leaf or leaf-stalk from *Palaquium gutta* is torn or broken asunder it is found that a number of tiny white threads, like a spider's web, stretch across the gap (Fig. 35, A, B, and C). They are formed by the coagulated latex contained in the sacs, of which I showed

⁽¹⁾ *Patent Specification* (No. 11,032 O.L.), of January 12th, 1846.



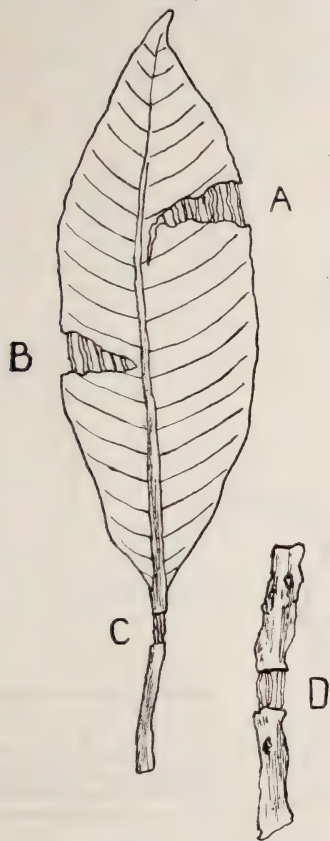
FIG. 33.—BRANCH AND LEAVES OF THE GENUINE GUTTA TREE. *Palaquium gutta* Burck.



FIG. 34.—BRANCHES OF INFERIOR GUTTA TREES. (*Dichopsis polyantha* Benth. *Dichopsis pustulata* Hemsl.)

you a microscopic section in the first lecture (Fig. 9, p. 119). In the case of a somewhat larger stem (Fig. 35 D), it requires some little force to overcome the resistance of these threads and to pull them asunder. On the other hand, if the leaf of an inferior gutta tree is similarly broken, very few, if any, such threads are visible, and accordingly very little gutta is found in them.

FIG. 35.



LEAF AND STEM OF PALAQUIUM GUTTA, SHOWING
THREADS OF LATEX.

A tree ten years old yields about 15 lbs. of dry leaves; one thirty years old, about 25 lbs., *i.e.*, 1 lb. more for every two years it advances in age. If, therefore, the leaves of a tree were regularly plucked every year from the age of ten till it reaches maturity at thirty, it would have produced 420 lbs. of them, and as I have found that the dry leaves contain between 9 and 10 per cent. of gutta percha, this would correspond to about 40 lbs., that is, at least twenty times as much as would be obtained from a tree of the same age, when felled and bled in the customary way. This result, even if only

partly realisable, would, in practice, be of enormous value to the gutta-planter.

Here is a large basket of leaves of *Palaquium gutta*, which formed part of a delivery of 20 baskets sent to us from Singapore for experiments in 1894. The contents of this basket weighs about 56 lbs., and would therefore yield about 5 lbs. of clean gutta percha. A similar basket filled with ordinary raw gutta percha would weigh about $1\frac{1}{2}$ cwts., and yield about 1 cwt. of clean gutta percha, taking the waste as $33\frac{1}{3}$ per cent. If the material is of 3^a quality it would, on extraction of the resin, give 75 lbs. of gutta comparable with that from leaves, which is nearly free from resin, or 15 times the amount bulk for bulk.

The large glass jar on the table is completely filled with leaves, and on the top you observe the comparatively small piece of raw gutta percha which contains the same quantity of clean gutta as the leaves. The difference in bulk between the two kinds of raw material is striking.

We shall now consider the various processes recommended for extracting the gutta from leaves, and I will first describe that proposed by Mons. Dieudonné Rigole¹ in March, 1892.

This inventor uses carbon disulphide for the treatment of the leaves; his apparatus is illustrated in Fig. 36; it somewhat resembles the Payen's percolator in the form given to it by Drechsel, and which you see here on the table. The pounded leaves are filled into the vessel, A, the boiler, B, contains the carbon disulphide, which is heated and vaporized by means of the hot-water bath, D. The vapours which pass through *a* are condensed in C, and the liquid percolates through the leaves and flows back charged with gutta through *a*₁ into the boiler. After exhaustion of the leaves, steam is admitted through *c*, and the disulphide from the leaves in A and the solution in B distilled off into the condenser, F. The gutta percha, remains in the boiler, floating on the condensed water from the steam.

The next process is one proposed by Mons. Hippolyte Eugène Sérullas¹ in June, 1892. The solvent used by this inventor is hot toluene. Fig. 37 is an illustration of the apparatus used for this process, copied from the patent specification, the apparatus I saw in actual use at Suresne-sur-Seine two years ago differing somewhat from the one here described. It was

¹ Engl. Pat. Spec. No. 4252, of March 3rd, 1892.

¹ Engl. Pat. Spec. No. 11,166 of June 14th, 1892.

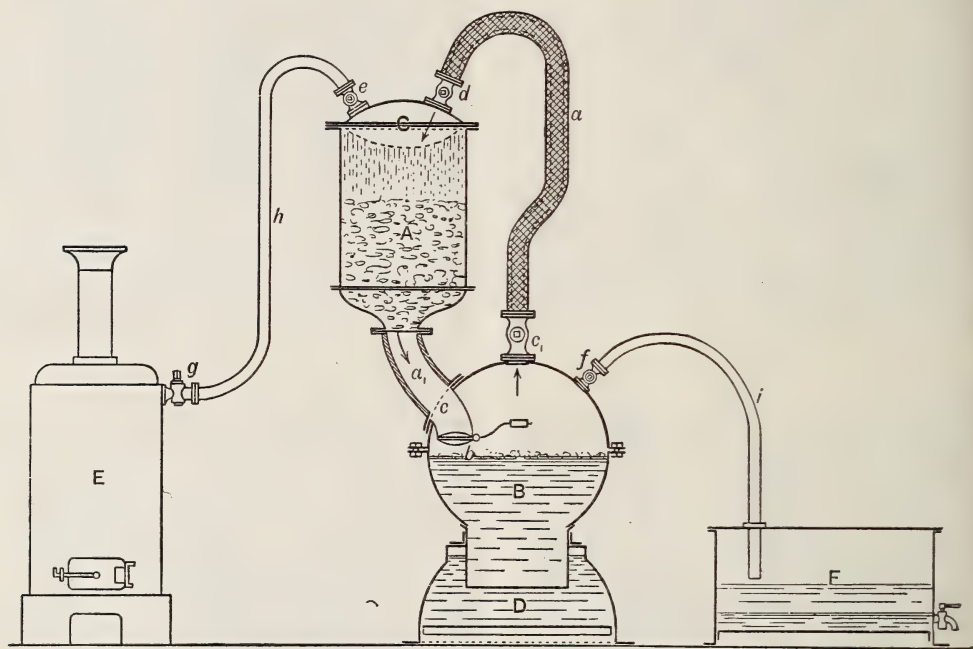
of rather large size, holding 500 kg. of pulverized leaves, and Mons. Sérullas stated that over eight charges could be treated in it every twenty-four hours. Referring to Fig. 37, the leaves are put in a jacketed digester, A, provided with an agitator, *a*. The toluene is filled into B, heated by means of external steam, and then abruptly discharged on to the leaves by means of the syphon, *b*. After allowing sufficient time to elapse for the toluene to act on the leaves, the solution is drawn off into the retort, D, where the solvent is removed by distillation. Later on, Sérullas¹

method myself, and cannot therefore express an opinion on its suitability for this purpose.

As you are no doubt aware, a company was floated only two days ago (December 4th), with the object of working M. Sérullas' process, on a commercial scale, and we will certainly wish it every success. The name of the company is the *Gutta Percha Corporation, Limited*, Lord Kelvin and Dr. Bottomley being consulting electricians, and Prof. Ramsay consulting chemist.

The next process is one which I devised myself about two years ago³. It is based

FIG. 36.



EXTRACTION FROM LEAVES BY RIGOLE'S PROCESS (MARCH, 1892).

introduced various improvements, and instead of distilling off the solvent, he now precipitates the gutta by means of acetone, and claims that in this way gutta percha is obtained which has exactly the same composition as that produced from the latex of the *Isonandra gutta* in the usual way, and no doubt the precipitated material is preferable to that obtained by evaporation of the solvent.

Prof. Ramsay² quite recently proposed *resin-oil* as a substitute for toluene for extracting the gutta from leaves, precipitating it with acetone like Sérullas; I have not tried this

on an observation made in 1881, viz., that gutta is readily soluble in light petroleum spirit at the boiling temperature, but is completely re-precipitated from this solution on cooling below 60° Fahr. The process is very simple, as only one liquid is required, whereas Sérullas uses two different liquids, which have afterwards to be separated again. Instead of pulverizing the leaves, which produces a large amount of fine dust, I crush them, with the stems, between closely set steel rollers, and thus render them very permeable to the solvent.

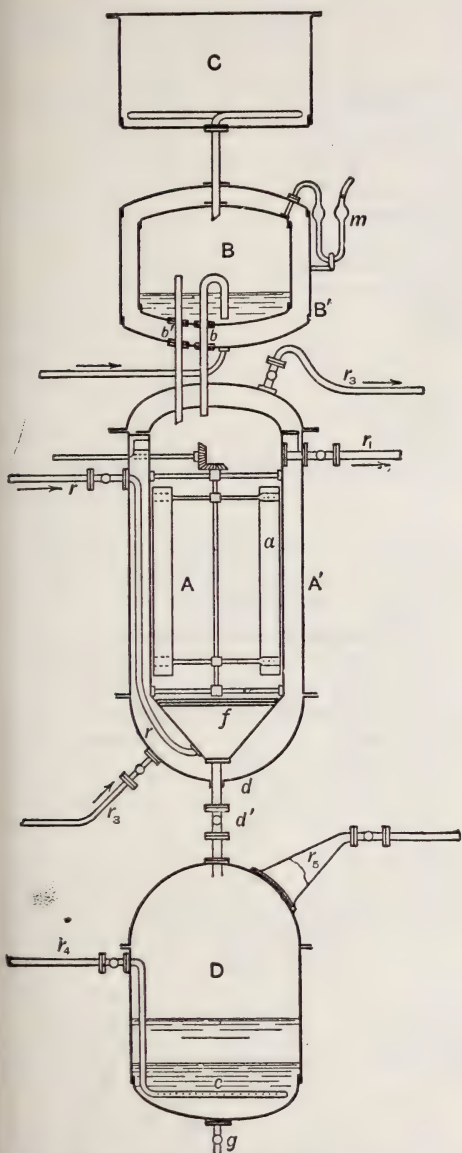
¹ *Engl. Pat. Spec.*, No. 654, of January 9th, 1896.

² *Engl. Pat. Spec.*, No. 17,936, of July 30th, 1897.

³ *Engl. Pat. Spec.*, No. 19,046, of August 28th, 1896.

The principle of the process is illustrated in Fig. 38, copied from the patent specification. The crushed and dried leaves are put into a basket made of perforated metal or wire gauze. This basket is lowered into one of the jacketed

FIG. 37.



EXTRACTION FROM LEAVES BY SÉRULLAS PROCESS.
(June, 1892.)

digesters, D_1 and D_2 , which is then filled with petroleum spirit from tank T_1 or T_3 . The spirit is heated to boiling temperature, by passing steam through the jacket of the digester, and the vapours are condensed in C , acting as a reflux-

condenser. After a certain time, the solution in the digester is allowed to cool a little, and is then drawn off into tank T_2 ; fresh spirit being then admitted and the operation repeated. After draining, the remaining solvent is distilled off from the leaves through C into tank T_4 , by means of direct steam, whereupon the exhausted leaves are removed. The gutta solution, which is kept slightly warm, is pumped up into tank T_3 , whence it flows either through a fresh charge of leaves, or, when sufficiently thick, is cooled down in one of the digesters, by passing water through the jacket to precipitate the gutta. The mother liquor is then drawn off into tank T_2 , the precipitate washed with clean spirit from tank T_1 , and allowed to drain. Steam is now admitted into the digester, to distil off the remaining spirit and the gutta, which is found floating on the condensed water, removed and washed. The two digesters are worked alternately.

Here are specimens of gutta percha, extracted from leaves by Rigole's, Sérullas', and my own process respectively. This specimen, which is in the form of a brick, was obtained by my process. As you observe it is of a very light colour; but still shows a slightly greenish tinge due to the presence of chlorophyll; however, some which we washed with particular care before the spirit was distilled off from the precipitate, looked decidedly better, and at the next lecture I will show you some of it rolled out into a thin sheet.

I am able to carry out the precipitation of gutta from solutions in your presence. This large vessel contains a solution prepared from leaves by means of hot toluene, and I will now pour twice its volume of acetone into it in the form of a spray, whilst I briskly stir the solution. After the lapse of a little time you will observe the precipitation of the gutta in the form of a white flocculent mass.

In this bottle is a solution of gutta, prepared by heating powdered leaves with petroleum spirit and straining the solution, which was then placed in ice. You notice the gutta has separated out in the form of a white powder. The solution in the other bottle is still clear, having been kept at a temperature above 60° Fahr. I now put it in ice and we shall examine it again at the end of the lecture.¹

¹ The gutta had then been precipitated voluminously. In the case of the solution in toluene, precipitation did not take place immediately after the addition of the acetone, but it occurred before the lecture was over, as was shown.

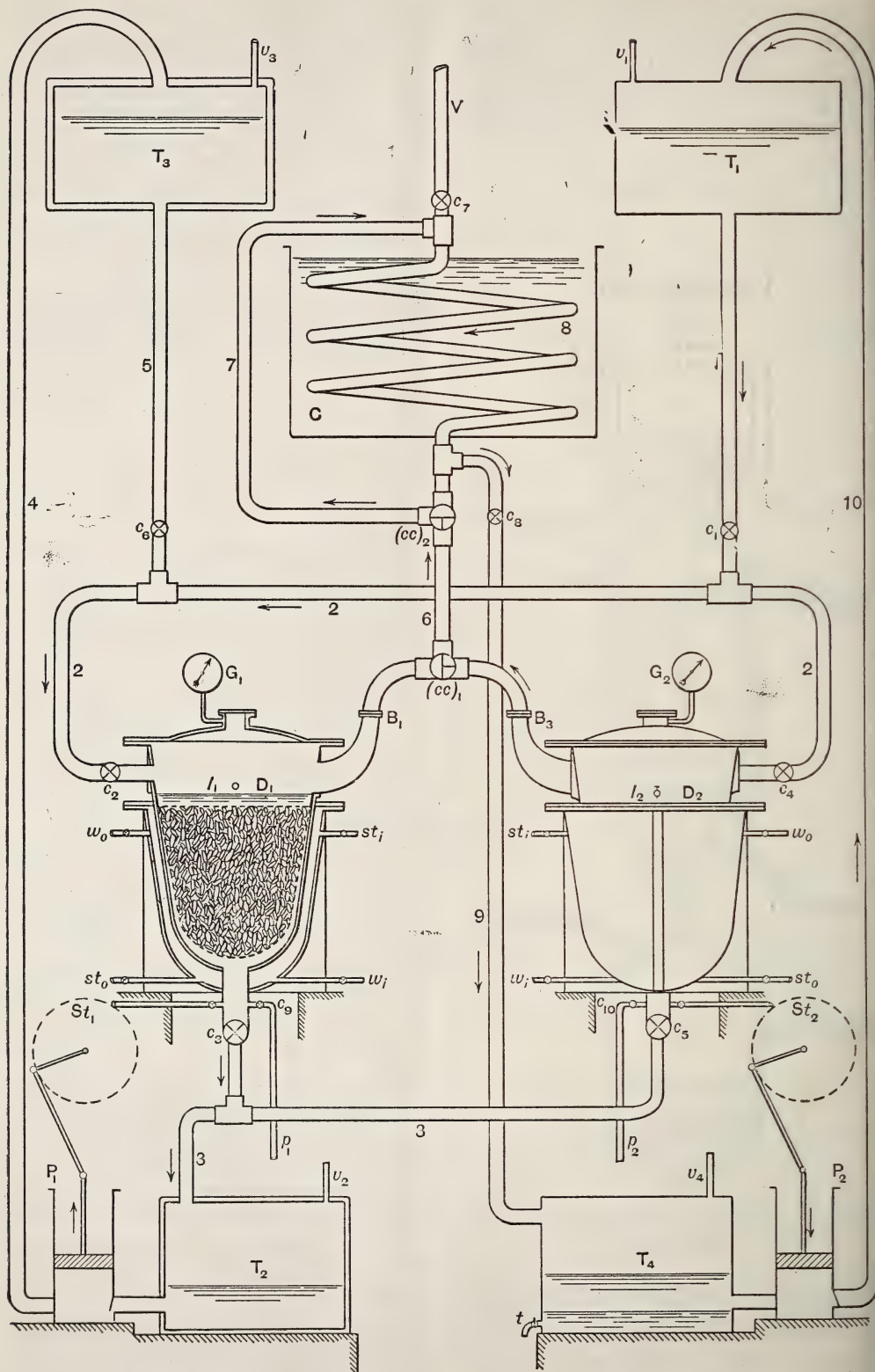


FIG. 38.—EXTRACTION FROM LEAVES BY OBACH'S PROCESS (AUGUST, 1896).

ADVANTAGES AND DISADVANTAGES OF THE DIFFERENT PROCESSES.

On reviewing the various processes used or recommended for extracting, purifying, and hardening gutta percha, one is struck by the fact that in almost every instance there are some disadvantages besides the advantages. The gutta percha extracted in a conscientious manner from the trunk of the right kind of tree possesses all the good qualities of this material, particularly that of durability, which is most valuable, but there is a risk of adulteration by admixture with juices from other plants, which are worthless or even detrimental; and moreover the destruction of the trees is, as has repeatedly been said, a most extravagant and wasteful proceeding. In that respect the extraction from detachable parts of the tree is certainly preferable; but as hitherto no satisfactory *mechanical* process has been proposed for that purpose, *chemical* methods have to be resorted to, as we have seen. This I consider to be a disadvantage, inasmuch as the durability of the gutta percha, particularly on exposure to air and light, is thereby imperilled.

The chemical *hardening* process differs from the chemical *extraction* process in so far that the salient constituent, *i.e.*, the gutta, is not affected by it, the solvent acting exclusively upon the resinous components. One point, however, must be taken into consideration, namely, that whatever the properties of the gutta itself may originally have been, they remain practically the same after the hardening process. By far the most (though not all) of the commoner sorts of raw materials, containing a large amount of resin, and which would recommend themselves for the hardening process, contain also a gutta of inferior description. Hence, in spite of the low percentage of resin which the hardened materials may contain, they cannot be considered fully equal to the superior kinds of gutta percha obtained directly from the tree. I shall, however, have something more to say about this subject in my next lecture.

NATURAL SUBSTITUTES.

I designate as *natural* substitutes those materials proposed as a substitute for gutta percha which are direct natural products, and which have been aptly termed *pseudo guttas* by Mr. James Collins. I can only consider a few of them to-night, and I shall more especially refer to those which have either been submitted to the Society of Arts or with

which I have become personally acquainted. The first material proposed as a substitute is the product of the common Indian Mudar-plant *Calotropis gigantea* Robert Brown which belongs to the *Asclepiadæ*; it was proposed in 1849 by Dr. Riddell,¹ a surgeon, in the Nizam army. Sir Richard Shakespeare,² the Resident of Gwalior, had the electrical properties of this gum tested, and found it to insulate badly; but he recommended the juice of the Mudar-plant for impregnating fibrous materials to render them elastic and waterproof. Mr. T. T. Henley and Captain G. E. Hollings,³ Deputy-Commissioner in the Punjab, proposed another substance, called "Garancine," obtained from the juice of the "Munjeet" or Indian Madder (*Rubia munjista* Roxburgh), and also the product of the "Alk" (*Calotropis Hamillonii* Wight).

I have not hitherto had an opportunity of testing either of these substances; but of those which I am now going to mention, I have had specimens for examination from the Kew Museum.

The first of these is the gum from *Dichopsis obovata* Teijsmann, found in the province of Mergui. Sir Archibald Boyle⁴ the Commissioner of Tenasserim, submitted a specimen of this "new kind of gutta percha" to Dr. Falconer, the Superintendent of the Honourable East India Company's Botanic Garden at Calcutta. It was handed for chemical analysis to Dr. Macnamara, who states in his report "that he does not hesitate to express his confident opinion that this new variety of gutta percha will be found to have all the useful qualities of that generally known and to be equally valuable." I have examined a specimen of this substance sent to Kew from the Indian Museum, but found it quite useless as a substitute, as it had neither strength nor tenacity. It is almost completely soluble in cold ether, and does not contain any appreciable amount of true gutta.

The next specimen I examined was a gum known under the name of "Pauchontee,"⁵ which had been submitted to the *Gutta Percha Committee* of the Society of

¹ *Journ. Agric. and Hort. Soc., India*, 1849, p. 51; *Journ. Soc. Arts*, 1883, vol. 1, p.p. 447,* 485*; see also *Kew Report* for 1881, p. 45.*

² *Vide* Mr. George Buist's letter to the Secretary of the Soc. of Arts, *Journ.* loc. cit., p. 611.*

³ *Journ. Soc. Arts*, loc. cit., p. 597.*

⁴ *Journ. Soc. Arts*, 1854, vol. 2, p. 540.*

⁵ *Vide* Dr. Cleghorn. "Memorandum upon the Pauchontee or Indian Gutta Tree of the Western Coast." Madras, 1858. Also James Collins, "Remarks on Pseudo-Guttas." *Journ. Soc. Arts*, 1883, vol. 32, p. 14.*

Arts³, by the Secretary of State for India in 1859, with a request for their opinion as to its quality and commercial value. Dr. Dugald Campbell,¹ to whom the specimen was handed for testing, found it hard and brittle at ordinary temperatures, and of little use for admixture with ordinary gutta percha. My own experience confirms this unfavourable report. The gum is the product of *Isonandra acuminata* Miquel or *Bassia elliptica* Dalzell, a tree which appears to be common on the Malabar coast, the forests of Coorg, at Travancore, &c.²

In 1849, Mr. Richard Spruce sent a sample of gum called "Massaranduba" to the Kew Museum³ from Para. This gum, which is derived from the cow-tree, *Mimusops elata* Allemão, I have recently examined, but found it resinous and brittle, and therefore of no practical use as a substitute for gutta percha.

We have next to consider the "gutta shea," the product of the shea butter-tree, or Karité, *Butyrospermum Parkii* Kotschy, which has been recommended as a substitute,⁴ and was very favourably reported upon by Dr. Edward Heckel,⁵ Professor of Botany at the Faculty of Sciences of Marseilles. The solid oil or fat of the shea butter-tree, which is largely used for soap-making, contains from 0.5 to 0.7 per cent. of a hydrocarbon said to be similar to gutta,⁶ and which has been termed "gutta shea." I have examined a specimen of the concrete milk from the trunk of the tree; also some of the gutta from shea butter, and some slightly fermented gutta from the trunk, which I received in 1891. They were taken from samples sent to the Kew Museum from Western Africa some years ago by Sir George Goldie, of the Royal Niger Company. Two of the samples contained about 14 per cent. of a substance somewhat resembling gutta, but possessing no strength or tenacity, and partaking more of the nature of a wax. The material could, therefore, hardly replace gutta percha, except, perhaps, for some special application. How-

ever, I should not like to express a definite opinion on this substance until I have examined it in a perfectly fresh and intact state. MM. Sérullas and Hourant¹ propose to extract the "gutta shea" from the raw material with toluene, and to precipitate the hydrocarbon from the solution by means of acetone, in the same way as they obtain the ordinary gutta from leaves.

The getahs of *Dichopsis Maingayi* and *Bassia Motleyana*, which I mentioned in my first lecture,² as well as some of those from Celebes, to which I then referred,³ may also be properly classed amongst the *pseudo-guttas*; but of those I examined, several, for instance the getah taban simpur from *Dichops. Maingayi* and two of the specimens from Celebes, contained an appreciable amount of real gutta, and might therefore be used for certain purposes in combination with a better-class gutta percha, or they could be freed from resinous matter by treatment with petroleum spirit as described to-night, and then used.

BALATA.

The only natural substitute for gutta percha with which I am acquainted, and which really deserves that name is *Balata*. It is the coagulated latex of a large forest tree, belonging to the *Sapotaceæ*, which is known under the name of "bullet tree," "bully tree," or "bolletrie." The botanical name is *Sapota Mülleri* Blume, *Mimusops globosa* Gaertner, or *Mimusops balata* Gaertner fil. The tree reaches, at maturity, a height of 120 feet, and usually has a large spreading head. Its cylindrical trunk is 60 to 70 feet high, and 4 to 5 feet in diameter. The wood is hard, dense, and has a reddish tinge, which accounts for the name of *paardenflesch* (horse flesh), given to it in the Dutch colonies. The glossy leaves are oblong-oval, 4 to 6 inches long, and 2 to 2½ inches broad; they are acuminate, petiolate, and alternate, being crowded together towards the ends of the branches. Fig. 39 shows a branch of the balata tree, with fruits, copied from the illustration accompanying an interesting article by Professor S. Bleekrode,⁴ published in 1857, and which is now very scarce. On the table there are some leaves of the balata tree,

¹ *Journ. Soc. Arts*, 1859, vol. 7, p. 223.*

² *Journ. Soc. Arts*, loc. cit., p. 553.*

³ Vide *Kew Report* for 1881, p. 44.*—2. *Kew Report*, loc. cit. p. 47, vide also John R. Jackson, "Commercial Botany of the Nineteenth Century," London, 1890, p. 35.*

⁴ Sir Joseph Hooker, *Kew Report* for 1878, p. 38*, loc. cit., 1881, p. 46.*

⁵ "Sur un nouvel arbre à gutta-percha," par E. Heckel. *Compt. Rend.*, 1885, vol. 100, p. 1238.* "Sur la gutta-percha de *Bassia Parkii* G. Don, et sur sa composition chimique," par Ed. Heckel et Fr. Schlagdenhauffen. *Compt. Rend.*, 1885, vol. 101, p. 1069.* Vide also *Le Petit Marseillais* for February 10th, 1891.*

⁶ J. R. Jackson, loc. cit., p. 24,* also *Kew Report* for 1878, p. 38.*

¹ *Engl. Pat. Spec.* No. 654* of January 9th, 1896.

² Vide p. 125, Table I., specimens No. 5 and 7.

³ Vide ante p. 111.

⁴ S. Bleekrode, "De Surinaamsche Getah Pertsja. *De Volkslijst*, Amsterdam, 1857, Nos. 6 and 7. I am indebted to Mr. van Eeden, of Haarlem, for the loan of a separate copy of this paper.

modelled in the gum itself, and presented to Kew in 1882, by Mr. E. Im Thurn, of Demerara; perhaps they give you even a better idea of their appearance than the drawing. Here are also branches of dried leaves, with flowers and fruits, from the Herbarium, and specimens of wood and bark of the tree from the Museum.

The flower is six-parted (hexamerous), the corolla being white and about $\frac{1}{2}$ in. long. The fruit is sometimes spherical, sometimes oval; it is edible, having a sweet taste like a plum. The milky juice which exudes from the trunk on incision is also consumed by the natives, who dilute it with water.

tained in the intermediate layer of the bark, it was formerly the custom in Jamaica to fell the trees and ring the bark, as described in the case of the true gutta trees; but this method has now been abandoned, and the trunk is simply tapped, which is quite practicable, as the balata milk is much more liquid than that of the gutta percha tree, as I stated in my first lecture.

In Surinam the trees are likewise tapped, or "bled," as it is technically called, the bark being scarified half round the tree to a height of about 20 feet from the base, and I will now show you some pictures¹ on the screen which illustrate the method of bleed-

FIG. 39.



BRANCH WITH FRUITS OF MIMUSOPS BALATA (GAERTN. FIL.).

The *Mimosa*æ are distributed all over the globe, and not long ago Dr. Schweinfurth found the leaves of *Mimosa Schimperii Hochstetter* within the wrappings of Egyptian mummies 4000 years old.¹

The bullet trees are found in Jamaica, Trinidad, Venezuela, British, Dutch, and French Guiana; they are also said to occur on the Amazon river. In the colony of British Guiana they are most plentiful between the east bank of the river Berbice and the Corentyn.

To obtain the latex, which is chiefly con-

ing in Surinam. The first (Fig. 40) shows the men in the act of cutting the grooves which are so arranged that the milk runs from one into the other till it reaches the lowermost.

The next picture (Fig 41) shows the tree after all the grooves have been cut in the trunk, and you observe the vessel or *calabash* at the bottom of the system of grooves, placed there

¹ These illustrations are from an article on "Balata" by Lieutenant A. N. De Balbian Verster in the Dutch Journal, *Eigen Haard*, published at Amsterdam, December 19th, 1896.

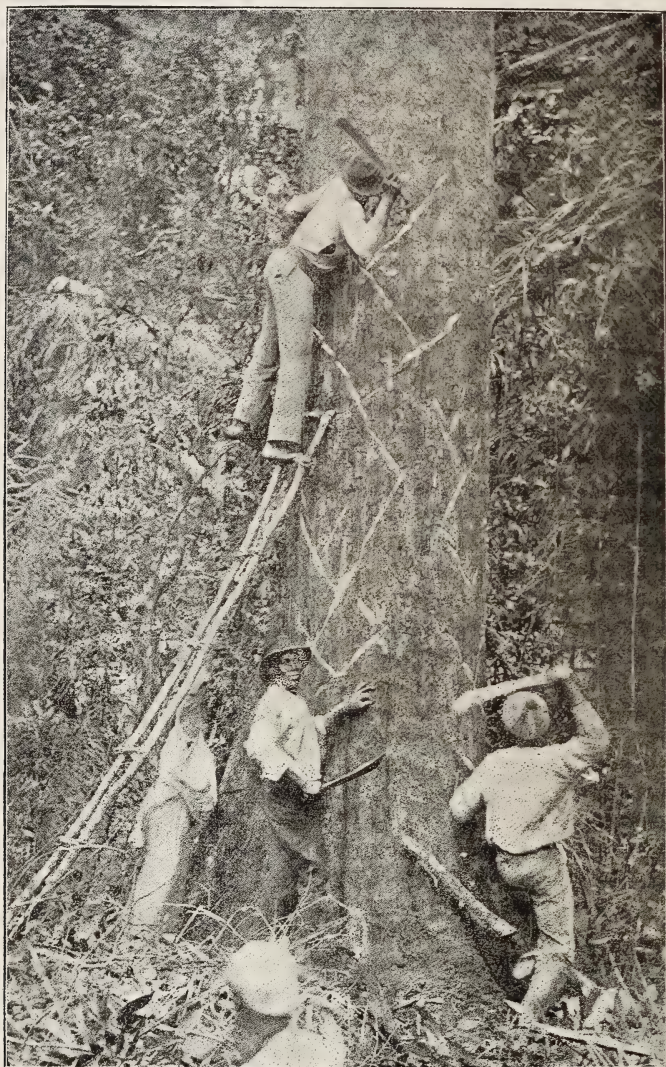
¹ *Nature*, 1886, vol. 34, p. 453*

to collect the milk flowing along them. The gang of men is in the act of leaving, in search of another tree. The contents of the *calabash* are emptied into another gourd provided with a handle, termed a *gooba*. Specimens of these utensils are here on the table. In the *gooba* the milk is taken to the settlement and either

very successful one as much as 10 gallons per day, thus realising over 30s.

I had the opportunity of examining some balata milk sent to the Colonial and Indian Exhibition at South Kensington in 1886. I found its specific gravity at 60° Fahr. to be 1.0063 and after evaporation on the water bath,

FIG. 40.



BALATA TREE BEING TAPPED BY NATIVES.

sold as it is, fetching about one dollar per gallon, or it is evaporated to obtain the (pinkish or greyish coloured) solid balata, for which 10d. or 11d. per lb. is paid. A gallon of milk yields about 4 lbs. of dry balata. A "bleeder" of average skill, obtains about 4 gallons, and a

I obtained about 60 per cent. of dry balata, which when analysed had practically the same composition as that of most commercial specimens.

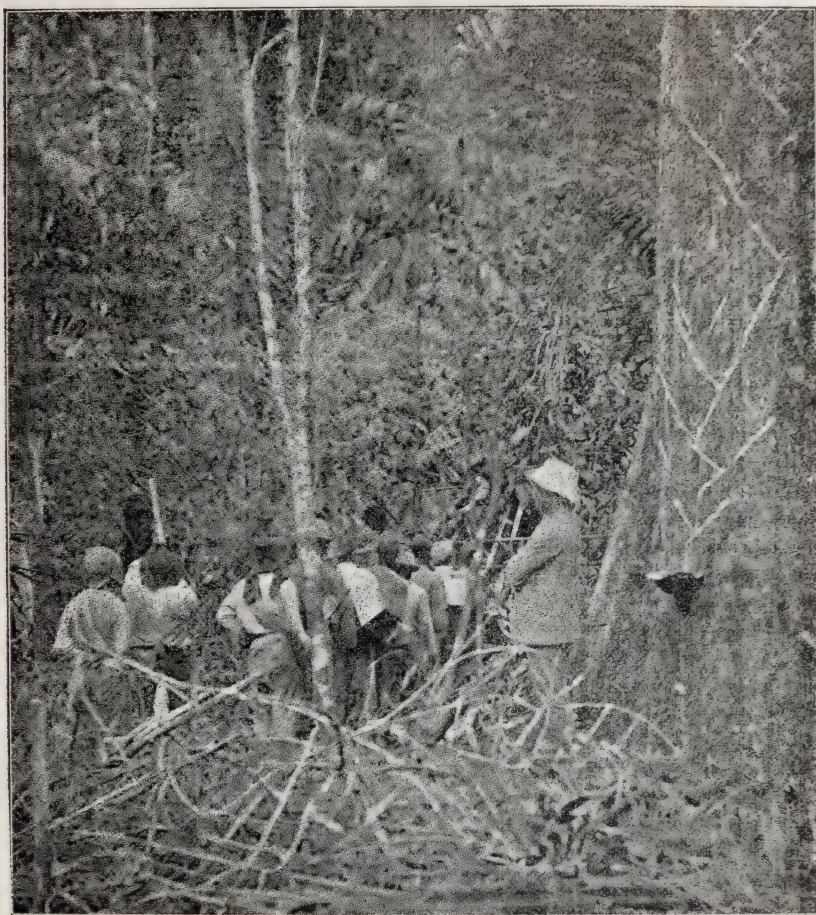
The first published records of balata are to be found in Prof. Bleekrode's paper

of 1857, mentioned above, and in a communication of his to the Society of Arts, made in the same year. From some chemical tests, he arrived at the conclusion that balata, or *Surinam gutta percha* as he called it, was identical with the product of the *Isonandra gutta*.¹

The Society of Arts again plays an important part in the early history of this interesting

February, 1864, from Sir William Holmes,¹ in response to the offer of a premium for substitutes for gutta percha, and in his letter to the Secretary, Sir William states that he had been Commissioner for British Guiana at the International Exhibition of 1862, at which he exhibited about $\frac{1}{2}$ -lb. of balata,² which had been submitted to Mr. Charles Hancock, who had expressed a favourable opinion on

FIG. 41.



BALATA TREE.—COLLECTING OF THE LATEX AFTER TAPPING.

substance. In August, 1860, the Colonial Secretary of British Guiana sent some balata which had been collected in Berbice by Dr. Van Holst, to the Secretary, Mr. Le Neve Foster,² and the specimens were afterwards forwarded to the Kew Museum. Other specimens were received by the Society in

it. This specimen also was afterwards forwarded to Kew. It is exhibited here to-night together with the historically valuable first

¹ These specimens consisted of the following, viz.:—(a) Bottle of milk as extracted from the tree by tapping; (b) Lumps or cakes (weighing together about 5 lbs.) prepared for the market; (c) Balls, to show the elasticity of the gum prepared by a special process.

² Reports by the Juries, London, 1863, Class IV., Section C, p. 47.*

¹ *Journal Soc. Arts*, 1857, vol. 5, p. 625.*

² *Journ. Soc. Arts*, 1860, vol. 8, p. 714.* *Journ. Soc. Arts*, 1864, vol. 12, p. 229.*

TABLE VII.—ANALYSES OF VARIOUS SPECIMENS

Ref. No.	Year submitted.	Name of country.	By whom submitted.	By whom received.	From whom obtained for analysis.	Year analysed.
1	1860	Berbice.	Dr. van Holst.	Society of Arts.	Mr. J. R. Jackson (Kew).	1886
2	1862	Brit. Guiana.	Sir Wm. Holmes.	Intern. Exh., 1862.	"	"
3	1868	Brit. Guiana.	James Collins.	Kew Museum.	"	"
4	1874	Trinidad.	J. R. Longden.	Foreign Office.	"	"
5	1882	Demerara.	E. F. Im Thurn.	Kew Museum.	"	"
6*	1884	Demerara.	G. S. Jenman.	Kew Museum.	"	"
7†	1884	Demerara.	G. S. Jenman.	Kew Museum.	"	1897
8	1886	Brit. Guiana.	The Commissioners.	Col. and Ind. Exh., 1886.	Mr. B. Howell Jones (London).	1897
9†	1896	Surinam.	Messrs. Tubergen and Daam.	Haarlem Museum.	Mr. F. W. van Eeden (Haarlem).	1897
10‡	1889-94	Mostly Brit. Guiana.	Various Importers.	London Docks and Warehouses.	Brokers and Agents (London).	1889-94

* Precipitated by spirits of wine.

† Lumps separated from samples of milk by spontaneous coagulation.

sample sent to this Society in 1860. Other specimens of balata were afterwards sent to Kew from British Guiana by Mr. James Collins in 1868, from Trinidad by Governor Longdon in 1874, from Demerara by Mr. E. Im Thurn in 1882, and by Mr. G. S. Jenman in 1884. The latter also sent a specimen obtained by precipitation with spirits of wine, and some of the milk itself.

All these specimens, with the exception of that submitted to the Society of Arts by Sir William Holmes in 1864, were analysed by me in 1886, in the manner described in my previous lecture. The results are shown in Table VII., which also gives the percentage composition of a sample of Surinam balata, recently obtained from the Colonial Museum at Haarlem, and the average result of analyses of 19 commercial samples of balata, received between 1889 and 1894 and representing about 50 tons. The average composition of balata is also graphically shown in Fig. 42 (p. 164), and is thus easily comparable with that of the various commercial brands of gutta percha, similarly depicted in the former lecture.¹ Referring to Table VII., specimen No. 6, from Jenman, is the one obtained by precipitation with alcohol, and No. 7, the gum separated out from the milk by spontaneous coagulation.

If these two specimens are disregarded, there is not very much difference between the other ones as far as the ratio between pure gutta and resin is concerned, the quality varying only between 4^a and 5. The larger amount of water which the commercial materials enclosed in comparison with the other specimens, is partly to be explained by the circumstance that the former were mostly analysed shortly after they arrived in London, whereas the other specimens had been in museums for many years before the analysis was made. The quality of the commercial balata as represented by Nos. 8, 9, and 10, viz., 4^a and 4^b is superior to that of any of the special samples 1 to 5.

The gutta contained in balata is very strong and tough, being altogether of excellent quality; but the percentage of resin is a large one, and the material can consequently only be regarded as a substitute for second, or perhaps even third class gutta percha. Balata is somewhat more flexible than gutta percha containing an equal amount of resin, which appears to be due to the softness of the resinous constituents. (I had several times observed an oily substance exuding from balata on stretching, which, after drying up, left a whitish powder behind, resembling mildew).¹ To determine the composition of

¹ Vide. Fig. 14, p. 129.¹ A loss in weight usually observed during analysis indicates the presence of volatile constituents.

AND SAMPLES OF BALATA (1886-1897).

Specimens as received.								Balata proper.					
Percentage composition.				Totals.		Ratios.		Percentage composition.		Quality.	Description of components.		
Gutta g.	Resin r.	Dirt d.	Water w.	Balata (G.+R.)	Waste (D.+W.)	Balata Waste	Gutta Resin	Gutta g.	Resin r.		Gutta.	Resin.	
43'2	40'3	14'5	2'0	83'5	16'5	5'1	1'1	51'7	48'3	4 ^c	Very light brown, brittle.	Very light brown, soft.	
47'4	43'6	8'3	0'7	91'0	9'0	10'1	1'1	52'1	47'9	4 ^c	Very light, elastic, good.	Very light brown, soft.	
43'3	41'6	13'0	2'1	84'9	15'1	5'6	1'0	51'0	49'0	5	Very light brown, brittle.	Nearly colourless, very soft.	
44'5	41'6	12'2	1'7	86'1	13'9	6'2	1'1	51'7	48'3	4 ^c	Very light, elastic.	Very light brown, soft.	
41'1	42'6	14'1	2'2	83'7	16'3	5'1	0'97	49'1	50'9	5	Very light, elastic.	Light yellow, soft.	
42'6	48'0	3'7	5'7	90'6	9'4	9'6	0'89	47'0	53'0	5 ^a	Nearly white, brittle.	Very light brown, hard.	
31'1	27'0	4'3	37'6	58'1	41'9	1'4	1'2	53'5	46'5	4 ^c	Very light, strong.	Pale yellow, hard.	
52'4	39'8	5'3	2'5	92'2	7'8	1'2	1'3	56'8	43'2	4 ^a	Very light brown, strong.	Light yellow, very soft.	
43'5	36'9	14'3	5'3	80'4	19'6	4'1	1'2	54'1	45'9	4 ^b	Very light, strong.	Yellow, very soft.	
41'4	34'8	9'9	13'8	76'3	23'7	3'2	1'2	54'3	45'6	4 ^b	Very light, strong.	Very light brown, soft.	

‡ The dirt was determined in a different portion, and the loss taken as water.
‡ Average of 19 commercial lots representing 50 tons.

the resin contained in balata, a specimen extracted with ether was carefully heated until the weight remained constant, whereby it lost 4'6 per cent. ; it was then repeatedly treated with boiling alcohol, from which the albane was precipitated on cooling as a white crystalline powder, leaving the fluavile in solution. It was then found that the resin consisted of about two parts of *albane* and three parts of *fluavile*.

I will now show you, that on heating, balata behaves pretty much like ordinary gutta percha. I plunge a piece into boiling water and you see it becomes quite soft and plastic; I now immerse it in cold water, and you observe that it slowly hardens again, but still remains flexible and elastic, showing no signs of brittleness.

the manufacturers against the material; but others retained their good qualities a long time, and I have here a sheet of balata, which was manufactured in January 1881, nearly seventeen years ago, and is still as sound as one could wish it. The sheet has been kept in a comparatively cool cellar, but without any special precautions. I am inclined to think that the materials which decayed so prematurely had either been carelessly prepared from the latex, or else were obtained by some special method of coagulation. I shall refer to the behaviour of balata towards atmospheric oxygen in my next lecture, and I will now conclude this subject by giving a few data about the price of balata, and the quantities exported from the two principal producing countries.

TABLE VIII.—BALATA EXPORTED FROM BRITISH GUIANA FROM 1885 TO 1896.

	1885.	1886	1887.	1888	1889.	1890-91.	1891-92.	1892-93.	1893-94	1894-95.	1895-96.	Total.
Quant. (cwts.). ...	496	606	723	2,219	3,245	2,025	1,039	2,120	1,832	1,867	1,424	17,596
Value (£)	2,113	2,979	3,498	14,069	15,652	10,078	6,807	11,296	8,283	11,484	8,023	95,182
Val. p. lb. (pence).	9'13	10'54	10'37	14'17	10'34	10'66	14'05	11'42	9'69	13'18	13'43	Average val. p. lb. 11'59

Some of the specimens of balata sent to this country perished quickly when exposed to air and light, and this rather prejudiced

In 1884, two samples sent to the Kew Museum by Mr. G. S. Jenman, were submitted to the India Rubber, Gutta Percha, and Telegraph

Works Company, Ltd., for trial, by Sir Joseph Hooker, and they reported that the materials lost 25 per cent. and 38 per cent. respectively on washing and drying, and valued them at 1s. 9d. and 1s. 3d. per lb.¹ The Silver-town firm took an interest in balata already at a very early date, and obtained specimens of it through Mr. David Melville in 1859, *i.e.*, before the first samples had been sent to the Society of Arts.

The price paid in London during the last 15 years for balata in "sheets" or "blocks," varied between 1s. 1d. and 2s. 6d., being on an average about 1s. 10d. per lb.

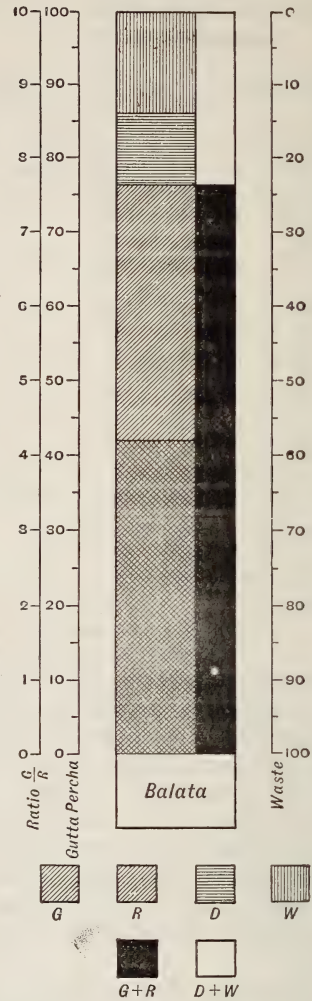
Table VIII. shows the quantities and values of balata, produced and exported from *British Guiana* for each year from 1885 to 1896, abstracted from the Government Reports on this Colony.

From 496 cwts. in 1885, the annual quantity gradually rose to a maximum of 3,245 cwts. in 1889, whereas it diminished again to 1,424 cwts. in 1895-96. The values per lb. given in the Table have been worked out from the total quantities and values of each particular year. They vary between 9d. and 14d., and are therefore notably less than the prices asked for the material by the dealers. The figures in Table VIII. only refer to the export of balata, actually *produced* in the English colony, and not to the *total* amount of this material exported from it, which is considerably larger.

Table IX. similarly shows the quantity and value of balata exported from the colony of *Dutch Guiana*, for each year from 1889 to 1896; the figures being taken from a report by

¹ *Vide* Mr. Jenman's valuable report on *Balata and the Balata Industry*, published in 1885, p. 16.*

FIG. 42.



PERCENTAGE COMPOSITION OF BALATA.

TABLE IX.—BALATA EXPORTED FROM DUTCH GUIANA FROM 1889 TO 1896.

	1889.	1890.	1891.	1892.	1893.	1894.	1895.	1896.	Total.
Quantity (cwts.)	30	1,502	1,882	2,375	641	2,132	2,631	2,480	13,673
Value (£).....	126	7,951	11,950	15,086	5,424	18,047	22,281	21,000	101,865
Estimated value per lb. (pence)*	9'07	11'34	13'61	13'61	18'14	18'14	18'14	18'14	Average value per lb. 15'96

* 9'07d. per lb. = 1 fl. per kg.
11'34d. " = 1½ fl. "

13'61d. per lb. = 1½ fl. per kg.
18'14d. " = 2 fl. "

Consul Churchill of Paramaribo, sent to the Marquis of Salisbury¹ in August, 1896. The figures for last year were obtained from

the Director of the Colonial Museum at Haarlem.

In the next and last lecture we shall deal with the properties and application of the cleaned material.

¹ Foreign Office, Miscellaneous Series, No. 406,* 1896.

Miscellaneous.

IRON ORE IN NORTH SWEDEN.

Dr. H. Lundbohm, the geologist, who was commissioned by the Swedish Board of Trade to report on the iron ore deposits of Kirunavaara and Luossavaara, has now published the result of his studies, and the following particulars are extracted from his interesting report in *Svenska Dagbladet* of December 31st last, as forming a useful supplement to the details of these deposits contained in the paper on the "Mining Industry of Sweden," read before the Society by Mr. Bennett H. Brough on December 8th.

The deposits, which are the largest of the kind in Europe, consist for the most part of magnetite, the remainder being red hæmatite mixed with magnetite. At Kirunavaara the deposit forms a wedge-shaped mass rising for some two miles to a mountain ridge, the height of which varies from 590 to 820 feet above the lake below. The deposit dips to the east at an angle of 50° to 60°, and its thickness varies from 110 to 500 feet. The thickness is found by diamond bore holes to diminish in depth, but there is estimated to be 215,000,000 tons of ore above the level of the lake, and there must be a considerable quantity below that level.

At Luossavaara the deposits are mostly covered with earth. The largest is 9 miles in length, and 100 to 180 feet in thickness. Borings indicate that the width decreases with increasing depth. The amount of ore above the level of the lake is estimated at over 18,000,000 tons.

With the exception of phosphorus, which is present in considerable quantities, the ores are free from impurities, and their per-centage of iron is extremely high. In more than sixty per cent. of the samples taken at Kirunavaara, it varied from 67 to 71 per cent. or more; whilst at Luossavaara the per-centage was found to vary between 67 and 70·55 per cent. Sulphur rarely exceeds 0·05 to 0·08 per cent., and titanium varies from 0·32 to 0·95 per cent. in the Kirunavaara ores, and from 0·95 to a little more in the Luossavaara ores.

Correspondence.

SELF-PURIFICATION OF SEWAGE.

We have heard a good deal lately of the purification of sewage by bacteria, and various elaborate names have been suggested for this process, showing all more or less the very deficient state of our knowledge of bacterial chemistry. In my humble judgment, the proper name, however, for the whole process is that adopted by me above, viz., *Self-purification of sewage*. As to the various phases and stages of

this process, we may well leave descriptive names until such times as more light has been thrown upon them; at the present time we know too little about them to mark the different stages definitely and precisely by different names, and, to my mind, any name should be descriptive of the changes that are brought about in the particular process to which it refers.

In the application of sewage to the land on sewage farms, we have the *natural self-purification of sewage*, whilst in all methods lately suggested (Sutton or Exeter principle) we have the *artificial self-purification of sewage*, and in connection with this latter process I would further suggest the names of *liquefying bed or tank* for bacteria bed or septic tank, and *purifying bed or tank* for filter or any other name.

It would lead much too far to deal with Dr. Rideal's paper in detail. I will only say in general that in my judgment the "artificial self-purification of sewage" has not yet entered upon a practical stage, and that before the ratepayers' money can be expended upon it on a large scale, we require a vast amount of further information as to the character of the effluent, its stability, its effect upon the organic matter and the animal and vegetable life in the stream into which it is discharged, as to the cost of the system, its working expenses, &c.

In reference to the working of the filters it is quite clear, from a recent letter of Mr. Dibden to the *Councillor and Guardian*, that they cannot be left to take care of themselves, but that, on the contrary, they must be very carefully superintended, which of course cannot be done without a corresponding expenditure.

Unfortunately, Dr. Rideal did not say in his paper that it was expressly stated at the Local Government Board inquiry at Exeter, by the engineering inspector, that if the Local Government Board did sanction the scheme at all, it would be on the distinct understanding that the effluent was further purified by land treatment. I think this is important, as otherwise mistaken opinions might be formed.

There is one point, however, on which, with your permission, I should like to make a few more detailed observations, and that is as to the origin of the knowledge that the purification of sewage is brought about by bacteria. Whilst I fully agree with Dr. Dupré's letter in your issue of the 24th inst. I am afraid it has escaped this gentleman's and Dr. Rideal's attention, that nearly 15 years before the date mentioned in Dr. Dupré's letter, Dr. Alexander Mueller discovered—if I may use the term—the fact that the self-purification of sewage is brought about by the micro-organic life it contains. This gentleman made so far back as 1869, experiments which were published in 1873 in "*Landwirtschaftliche Versuchstationen*," vol. 16, and on page 263 of this publication Mueller remarks as follows:—

"The contents of sewage are chiefly of organic origin, and in consequence of this an active process of

decomposition takes place in sewage, through which the organic matters are gradually *dissolved* into mineral matters, or, in short, are mineralised and thus become fit to serve as food for plants. To the superficial observer this process appears to be a chemical self-reduction; in reality, however, it is chiefly a process of digestion, in which the various—mostly microscopically small—animal and vegetable organisms utilise the organically fixed power for their life purposes."

And again:—

"The decomposition of sewage in its various stages is characterised by the appearance of enormous numbers of spirillæ then of vibrios (swarming spores) and finally of moulds. At this stage commences the reformation of organic substance with the appearance of the chlorophyl holding *Protococcus*, &c."

Some time afterwards Mueller took out a patent, in which he endeavoured to utilise the micro-organic life in sewage for the purpose of purification, and which I believe was actually in operation at one time to purify the effluent of some works for the manufacture of sugar from beetroot.

F. Emich appears after Mueller to have been the next to draw attention to the agencies by which the self-purification of the sewage is brought about, for his investigations were published in 1885 in "*Monatshefte*," vol. 6, p. 77 (see also "*Chemisches Central Blatt*," 1885, p. 333). He examined the changes taking place in water when left standing exposed to air, and after agitation with air. He further experimented with sterilised water, and investigated the behaviour of water to ozone and hydrogen dioxide.

When left standing, and after agitation with air, the self-purification only took place if the water had not been sterilised through boiling and had not been protected against the entrance of germs during the period of observation. If, however, sterilised water was afterwards fully exposed to the air, or if it was afterwards infected with ordinary water, the same changes took place in it as in non-sterilised water exposed to air, viz.: the quantity of potassium permanganate required for the oxidation of the organic matter, and the amount of ammonia decreased with the formation of nitrous and nitric acid. A direct oxidation through the oxygen of the air did not take place; and even one brought about by ozone and hydrogen dioxide, plays only an unimportant part compared with that played by the biological process.

I think I have given sufficient information to prove that our knowledge of the self-purification of sewage through the micro-organic life it contains dates back at least to the year 1873, and that some time after that year an attempt was made to utilise these forces on a practical scale.

H. ALFRED ROECHLING.

Leicester,

28th December, 1897.

THE PURIFICATION OF SEWAGE BY BACTERIA.

I have read both Dr. Rideal's interesting paper on this subject and the letter from Dr. Dupré, which appeared in your issue of the 24th ult., and whilst I cannot agree with the former that "until quite recently it was believed that the purification of sewage was simply a process of oxidation," I am equally unable to allow Dr. Dupré's claim—for such it must be regarded—to the origination of the idea on which the so-called biological treatment of sewage is based. He alleges that since 1884 or 1885 he has "by speech and writings, endeavoured to convince chemists and engineers that the essential agents concerned in the treatment of sewage were living organisms." This may be readily granted, and no one will question the value of the help rendered by Dr. Dupré to the elucidation of the troublesome problems involved in the subject under consideration, but at the same time, he does not stand alone, and many others must also be credited with the same views and teaching. I have no desire to set up a counter-claim, the fact being that such ideas are the outcome of gradually expanding information, and are necessarily more or less common to many workers and thinkers in the same field. I may therefore be allowed to point out that long before 1884 or 1885 I had advocated the same view. Even so early as in 1878 I had, in my work on "*Animal Chemistry*" (Longmans and Co.) p. 444, given an account of the changes that may be assumed to happen in organic matters when exposed to the air, pointing out that in the first place, complex molecules, such as albumin, are broken up through the agency of certain living organisms into simpler compounds, which are then attacked by other forms of micro-organic life, "the whole being supplemented by further changes induced by the presence of air and water." Later on, viz., in 1880, I communicated to the Chemical Society a short paper on the "*History of Putrefaction*" ("*Journ. Chem. Soc.*," 1880, pp. 15-22), which dealt to some extent with the oxygen-absorbing capacity of liquids in course of destructive changes by the influence of bacteria; while in the same year, in the first edition of my work on "*Nature's Hygiene*" (Bailliere and Co.), p. 55, I wrote as follows:—

"It appears from the life-long labours of Pasteur that the process of slow oxidation really depends upon the development of organisms in the interior or upon the surface of matters which are in process of decomposition, and that in the absence of such organisms, slow oxidation or combustion cannot occur. Just as the acetification of wines or beer depends upon vegetable growths (such as *mycoderma vini*) which possess the property of exciting oxidation in the solutions into which they may be introduced, so all other processes of slow combustion depend upon similar causes; and here we get a glimpse of the inutility of using agents like carbolic acid for the destruction of such vegetable ferments. For these

ferments are ubiquitous, and have a great function: it is their natural work to cause slow oxidation in refuse matter, that is to say, in matters of animal and vegetable origin; and if we could by any possible means exterminate this branch of natural beings, we should interfere with the way which was originally created and intended to serve as a sanitary measure for human welfare."

It will be at once apparent that this statement—to copy Dr. Dupré's expression—also "covers the whole ground and clearly states the principles on which the biological treatment of sewage is based."

It seems to me that Dr. Dupré does not give due credit to the earlier work of Frankland on intermittent filtration in which the agency of micro-organisms was clearly demonstrated, particularly in the direction of what is now better understood as "nitrification."

To sum up, there is, so far as I can see, no new idea in the so-called biological treatment of sewage, but merely the better application of principles which were made originally clear by the classical researches of Pasteur. Many of us have driven a nail home here and there, but there is nothing absolutely new in the sewage treatment of to-day, nor can any of us lay claim to any originating idea.

C. T. KINGZETT, F.I.C.

Elmstead Knoll, Chislehurst.

Jan. 5th, 1898.

General Notes.

FRENCH WINE PRODUCTION IN 1897.—The French "Direction Générale des Contributions Indirectes" have just finished their annual labours in connection with the estimate of the wine yield in France, and for the year 1897 this yield is calculated at 32,351,000 hectolitres (711,722,000 gallons), a falling off of 270,710,000 gallons as compared with the harvest of 1896, and 2,772,000 gallons below the average of the last ten years. In adding 87,714,000 gallons for Algeria, according to the provisional estimates, and about 6,600,000 gallons for Corsica, a total is arrived at of about 806,000,000 gallons. Increased production is shown in eighteen departments, particularly in the six departments of the Midi (Aude, Bouches-du-Rhône, Gard, Hérault, Pyrénées-Orientales, and Vaucluse), chiefly due to the reconstruction of the vineyards and the favourable atmospheric influences. In the remainder of the territory, the frosts of the spring and the cold rains of the latter part of the summer had the most disastrous results. According to alcoholic strength, the wines of 1897 are sub-divided as follows:—Wines of less than 11 degrees of strength, 638,418,000 gallons; wines of 11 degrees, 52,140,000 gallons; wines over 11 degrees, 21,164,000 gallons. The value of the wine harvest is estimated at £32,868,000.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

JANUARY 19.—"The Projection of Luminous Objects in Space." By ERIC STUART BRUCE, M.A.

JANUARY 26.—"Fireproof Construction of Domestic Buildings." By THOMAS POTTER.

FEBRUARY 2.—"The Cinematograph." By JULES FUERST. CAPTAIN W. DE W. ABNEY, C.B., F.R.S., will preside.

FEBRUARY 9.—"Compensation to Workmen." By A. D. PROVAND, M.P.

FEBRUARY 16.—"The Protection of Industrial Property." By J. F. ISELIN, M.A., LL.M.

FEBRUARY 23.—"Children's Sight." By R. BRUDENELL CARTER, F.R.C.S.

Dates to be hereafter announced:—

"Kites: their Theory and Practice." By Captain B. F. S. BADEN-POWELL.

"Stage Mechanism." By EDWIN O. SACHS.

"The Recent History of Papermaking." By CLAYTON BEADLE.

"The Preparation of Meat Extracts." By C. R. VALENTINE.

"The Production of Low Temperatures." By Professor J. A. EWING, F.R.S.

"Aerial Telegraphy." By Professor SILVANUS P. THOMPSON, F.R.S.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock:—

JANUARY 20.—"Recreations of an Indian Official." By the Right Hon. Sir MOUNTSTUART ELPHINSTONE GRANT DUFF, G.C.S.I., C.I.E., F.R.S. The Right Hon. LORD GEORGE HAMILTON, M.P., will preside.

FEBRUARY 17.—"The Plague in Bombay." By HERBERT MILLS BIRDWOOD, C.S.I., M.A., LL.D. (late Governor's Council, Bombay).

MARCH 10.—"India and Sir Henry Maine." By CHARLES LEWIS TUPPER, C.S.I. The Right Hon. Sir MOUNTSTUART ELPHINSTONE GRANT DUFF will preside.

MARCH 31.—"The Earthquake in Assam." By HENRY LUTTMAN-JOHNSON, I.C.S.

APRIL 21.—"The Rise, Progress, and Present Position of the Native Press of Western India." By R. P. KARKARIA (of Bombay).

APRIL 28.—"India and Currency." By Sir EDWARD SASSOON, Bart.

MAY 19.—Paper by Sir ALFRED COMYNS LYALL, G.C.I.E., K.C.B., D.C.L. (Member of the Council of India). (Title to be announced.)

The meetings of January 20, February 17, and March 31, will be held at the Imperial Institute; those of March 10, April 21, April 28, and May 19 at the Society of Arts.

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesday afternoons at 4.30 o'clock :—

JANUARY 18.—“My Recent Journey from the Nile to Souakim.” By FREDERIC VILLIERS.

FEBRUARY 15.—“The Goldfields of Klondyke and British Columbia.” By W. HAMILTON MERRITT.

MARCH 15.—“The African : what he is, and what he is capable of becoming.” By the Rev. GODFREY DALE (Universities Mission to Central Africa).

APRIL 5.—“The Sugar Industry in the West Indies.” By T. R. TUFNELL.

APPLIED ART SECTION.

The meetings of this Section will take place on the following Tuesday evenings, at 8 o'clock :—

JANUARY 25.—“Renaissance Woodwork in England.” By J. HUNGERFORD POLLEN. WILLIAM LUSON THOMAS, R.L., will preside.

FEBRUARY 22.—“The Regalia of England.” By CYRIL DAVENPORT. SIR GEORGE BIRDWOOD, K.C.I.E., C.S.I., will preside.

MARCH 8.—“The Making of a Stained Glass Window.” By LEWIS FOREMAN DAY.

MARCH 29.—“English Art in Illuminated MSS.” By Sir EDWARD MAUNDE THOMPSON, K.C.B.

APRIL 26.—“The Importance of Craftmanship.” By Sir WILLIAM BLAKE RICHMOND, R.A., K.C.B.

MAY 17.—“Practical Points in Italian Majolica Painting.” By WILLIAM BURTON, F.C.S.

CANTOR LECTURES.

The following courses of Cantor lectures will be delivered on Monday evenings, at Eight o'clock :—

CYRIL DAVENPORT, “Decorative Book-binding.” Three Lectures.

LECTURE I.—JANUARY 24.—The beginnings of bookbinding—Assyrian clay tablets in their cases—Egyptian papyrus rolls—Vellum rolls—Roman diptychs—Mediaeval bindings in carved ivory, and metal covers with gems and enamels—Decorative bindings in Europe and the East up to and including the 15th century.

LECTURE II.—JANUARY 31.—Decorative book-binding in Continental Europe, chiefly Italy, France, and Germany, from the 16th to the 18th centuries inclusive, with some notice of Oriental bindings.

LECTURE III.—FEBRUARY 7.—Decorative book-binding in England from the 16th to the 18th century—Gold and enamelled bindings made for Henry VIII. and Queen Elizabeth—Bindings embroidered on velvet of the Tudor period, and on satin during the 17th century—Gold tooled work by Thomas Berthelet in the 16th century, by Samuel Mearne in the 17th century, and by Roger Payne in the 18th century, and the influence of these great binders upon the art.

HUGH STANNUS, “The Principles of Design in Form.” Four Lectures.

February 14, 21, 28, March 7.

PROF. W. NOEL HARTLEY, F.R.S., “The Thermo-Chemistry of the Bessemer Process.” Three Lectures.

March 14, 21, 28.

DR. D. MORRIS, C.M.G., “India Rubber.” Two Lectures.

April 18, 25.

PROF. CARUS WILSON, “Electric Traction.” Four Lectures.

May 2, 9, 16, 23.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JAN. 10.—Imperial Inst., South Kensington, 8½ p.m.

Mr. H. C. Richards, “Western Australia : its Growth and Possibilities.”

Surveyors, Savoy-street, W.C., 8 p.m. Adjourned Discussion on Mr. F. Punchard's Paper, “The Royal Commissioners' Suggested Amendments to the Agricultural Holdings Act, 1883.”

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m.

Mr. F. C. Selous, “Travel and Adventure in South Africa.”

TUESDAY, JAN. 11.—Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. E. W. Anderson, “The Machinery used in the Manufacture of Cordite.”

Photographic, 12, Hanover-square, W., 8 p.m. Dr. F. Hurter and Mr. Driffeld, “The Latent Image and its Development.”

Anthropological, 3, Hanover-square, W., 8½ p.m.

Biblical Archaeology, 37, Great Russell-street, W.C., 8 p.m. Annual Meeting.

Colonial Inst., Whitehall-rooms, Whitehall-place, S.W., 8 p.m.

Asiatic, 22, Albemarle-street, W., 4 p.m.

WEDNESDAY, JAN. 12.—SOCIETY OF ARTS, John-street, Adelphi, W.C., 7 p.m. (Juvenile Lecture) Prof. Ramsay, “Fire.” (Lecture II.)

Royal Literary Fund, 7, Adelphi-terrace, W.C., 3 p.m.

United Service Institution, Whitehall, S.W., 3½ p.m.

Royal Society of Literature, 20, Hanover-square, W., 1 p.m.

THURSDAY, JAN. 13.—Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 6 p.m. Mr. Albert Vandam, “An Englishman in Paris.”

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Inaugural Address by the President, Mr. J. W. Swan.

Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, JAN. 14.—Civil Engineers, 25, Great George-street, S.W., 8 p.m. (Students' Meeting.) Mr. R. Gordon Mackay, “Mechanical Draught.”

Astronomical, Burlington-house, W., 8 p.m.

Philological, University College, W.C., 8 p.m.

Clinical, 20, Hanover-square, W., 8½ p.m.

SATURDAY, JAN. 15.—North-East Coast Institute of Engineers and Shipbuilders, Technical College, West Hartlepool, 8 p.m.

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No. 2,356. VOL. XLVI.

FRIDAY, JANUARY 14, 1898.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****JUVENILE LECTURES.**

On Wednesday evening, 12th inst., Professor WILLIAM RAMSAY, Ph.D., F.R.S., delivered the second and last lecture of his course on "Fire," in which he dealt with fire as associated with electricity. He showed, by means of an induction coil, how a sort of miniature lightning was formed. The destructive effects of lightning could be imitated, for the sparks would pass through paper and puncture it with holes; but if a sheet of ebonite replaced the paper, the sparks would not pass through this, but played round it. When the alternating current from the street electric mains was passed into the coil, an actual flame was produced between the terminals, the nitrogen and oxygen of the air being set on fire, and the flame could be blown out and relighted by a match.

It was then demonstrated that every gas has its own colour and the red colour of argon was shown in the tube; when the current was made hotter by means of a Leyden jar the colour turned to blue. It was at first supposed that these two colours indicated the existence of two separate gases, but this view is not accepted now. It was from observation of the colour that Lord Rayleigh and Prof. Ramsay were led to the discovery of argon.

The lecturer then referred to the physical constitution of the sun, and pointed out that the flames from the sun had been first observed in connection with the eclipse of the sun. He then showed a continuous spectrum by means of a beam of light from the oxy-hydrogen light, and afterwards interposed three spirit lamps, the wicks of which had been soaked in salt, when the spectrum was broken by the sodium line.

The phenomena of phosphorescence were then exhibited, and the lecture ended with the exhibition of the Röntgen rays.

The CHAIRMAN proposed a vote of thanks to Professor Ramsay for his interesting course of lectures, which was carried unanimously.

EXHIBITION OF BOOKBINDINGS.

In connection with Mr. Cyril Davenport's Cantor lectures on "Decorative Bookbinding," an Exhibition of specimens of Foreign and English Ornamental Bindings to the end of the eighteenth century will be held in the Reading Room of the Society. The Exhibition will be open daily from Monday, 24th inst. to Monday, February 7th. Hours: 10 to 5 p.m., and on the evenings of the lectures.

Members can admit their friends by the use of the usual meeting tickets supplied to members. There will be no restriction as to the number of tickets issued.

Proceedings of the Society.**CANTOR LECTURES.****GUTTA PERCHA.**

BY DR. EUGENE F. A. OBACH,
F.I.C., F.C.S., M.I.E.E.

Lecture III.—Delivered December 13, 1897.

THE CLEAN MATERIAL.—Chemical composition and analysis—Physical and mechanical properties—Electrical properties—Application for various purposes—Home consumption—Use of hardened gutta percha—Absorption of oxygen—Behaviour towards ozone—Deterioration and preservation—Artificial substitutes—Concluding remarks.

Last Monday, I told you that it was Mr. Charles Hancock who first devised special machinery for cleansing and purifying raw gutta percha, which, more or less modified, is still in use at the present time, and we shall presently see that to him is also due the honour of having obtained the first patent for the practical application of gutta percha. Again it was at the *Society of Arts* that Mr. Hancock obtained his first specimen for experiment. It was given to him by Mr. Henry Gouger¹, at a conversazione, probably held during the winter 1843-44, and his son, the Rev. Thomas Hancock, informs me, that he well remembers his father's great delight on first becoming acquainted with the new substance, and his sanguine prediction of the many uses to which it could be applied.

It occurred to me that it might interest you to see Mr. Hancock's portrait², and I had a lantern slide made from a photograph kindly lent me by his niece Miss Maria Hancock. Mr. Hancock was by profession an artist; he

¹ Vide Mr. Hancock's letter to the editor *Journ. Soc. Arts* 1862, vol. 10, p. 366.*

² Will be reproduced in the Appendix.

was born at Marlborough on December 16th, 1800, and died at Blackheath on July 30th, 1877.

CHEMICAL COMPOSITION AND ANALYSIS.¹

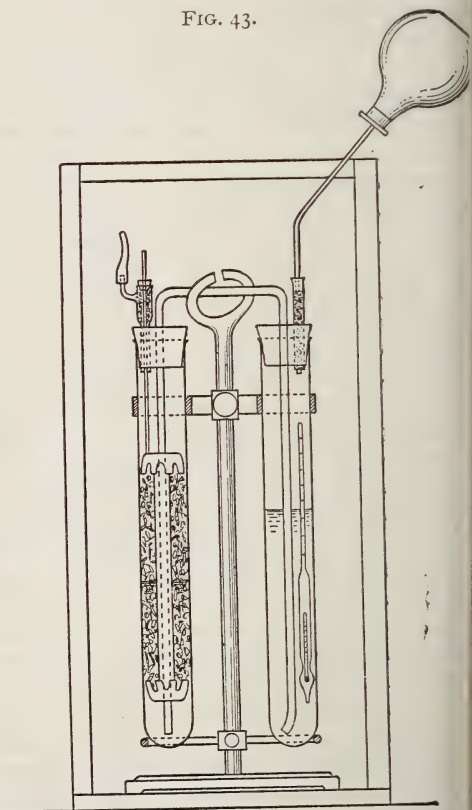
We have now to consider the *composition and analysis* of cleaned gutta percha. Here we find the same components as in the raw material, viz., gutta, resin, dirt and water. The gutta and resin are unchanged and in the same relative proportion as before; but the dirt now consists chiefly of colouring matter (*phlobaphenes*) and finely ground bark and wood, which are uniformly disseminated in the material, and impart to it the characteristic reddish or chocolate-brown colour.²

The amount of dirt remaining in gutta percha after thorough mechanical cleaning, depends essentially on the nature of the material, some kinds parting with their impurities much more readily than others. This likewise applies to the water left in gutta percha after mastication, some sorts giving it off without difficulty, whereas others tenaciously retain it.

The analysis of clean gutta percha may be carried out in much the same way as that of the raw material, as described in the first lecture (pp. 124 and 125 *ante*). The gutta percha, preferably in the form of thin sheet, is cut up into small pieces and divided into two portions. In one, the water is determined by heating it in a current of rarefied air or hydrogen and absorbing the moisture with sulphuric acid in a weighed U-tube; in the other, the resin, gutta and dirt are determined. The resin is extracted by means of cold ether, the solution distilled and the residue carefully heated and weighed. The gutta and dirt remaining after the extraction of the resin are dried in vacuo and weighed so as to check the other result; the gutta in its turn is then dissolved in carbon disulphide or chloroform, the solution filtered, and the solvent distilled off. The gutta thus obtained is dried in vacuo and weighed, and is then softened and pressed into the form of a plate, which is tested for elasticity and strength. In order to facilitate the separation of the dirt

from the gutta solution, the latter is either subjected to the action of a centrifugal machine or it is mixed with alcohol or water, according as the solution has been made in carbon disulphide or chloroform respectively. On standing, the two liquids separate again, and the lighter one, on rising to the top, carries the dirt with it; the clear solution can then be drawn off at the bottom. In this way results can be obtained which are sufficiently accurate for most practical purposes; although, scientifically speaking, they are not strictly accurate, inasmuch as the resin is not completely separated from the gutta, and the latter still contains a certain amount of colouring matter. However, these disadvantages are more than balanced by the great convenience of this method for daily use in the laboratory, in comparison with the other method of precipitating the pure gutta with alcohol.

FIG. 43.



APPARATUS FOR APPROXIMATE ANALYSIS OF GUTTA PERCHA.

For such cases, where it suffices to ascertain approximately the percentage of resin in clean gutta percha, I devised some years ago a rapid method, which is based on the increase of the specific gravity of a solvent, ether for instance, through the presence of resin. The apparatus

¹ The lecturer before entering on his special subject, called attention to two specimens of gutta obtained from leaves and precipitated from solutions at the last lecture. Both precipitates, viz. the one obtained from a solution in toluene by means of acetone, and the other from a solution in petroleum spirit by cooling, had since been washed, and now presented a much cleaner appearance.

² The *phlobaphenes* are soluble in alkaline solutions, and are therefore extracted during the chemical washing process, described in the last lecture. They can be precipitated from the washings in the form of brown flocculi by the addition of acids

(Fig. 43) consists of two glass tubes, closed at their lower ends and provided with caoutchouc stoppers, through which the two ends of a narrow glass tube, bent in the form of a $\cap$, pass. A weighed quantity of gutta percha, cut up into very small pieces, is put into one of the larger tubes, and a measured quantity of ether into the other. The ether is then driven over into the first tube and left for a certain time in contact with the gutta percha. It is then driven back and its specific gravity measured with a special hydrometer, which is provided with a thermometer. The apparatus stands in a wooden box, with glass windows back and front, so as to ensure uniformity of temperature, and special precautions are taken to guard against loss by evaporation, &c. Tables have been prepared for use with this apparatus, by means of which the percentage of resin can be directly read off from the increase of specific gravity.

PHYSICAL AND MECHANICAL PROPERTIES.

The *physical and mechanical* properties of gutta percha depend chiefly on its chemical composition, *i.e.* upon the relative proportion of gutta and resin, or ratio $\frac{G}{R}$; but as far as the specific gravity is concerned, the constitution of the resin, and probably that of the gutta also, asserts itself. The specific gravity of gutta percha of average composition is practically the same as that of water; but the individual brands differ somewhat from each other, some being lighter and others heavier than water. In this bottle I have a number of small spheres of different kinds of gutta percha, immersed in distilled water, and you observe that most of them float; but a few have sunk to the bottom. Table X. gives the specific gravities of twelve different sorts, including an average material, obtained by mixing different brands in the masticator, after they had been cleaned. The Table also gives the specific gravity of gutta percha obtained from leaves by my process, as well as those of balata and Para-caoutchouc, for comparison. It will be seen that by far the lowest specific gravity is that of the material obtained from leaves, the "soondie" following next, then the "genuine" and finally the "Bulongan white" and "mixed white," which are the heaviest. The gutta percha used for these determinations was in the form of sheet 2.2 mm. thick, and the air was completely removed from the strip under the receiver of an air-pump, before the final weighing was

taken. The temperature of the water was accurately adjusted to 15°C , and the specific gravities given in the Table are those compared with water of that temperature. The Table further gives the ratio $\frac{G}{R}$ for each material. The complete analysis, including a determination of the ashes, will be given in the Appendix.

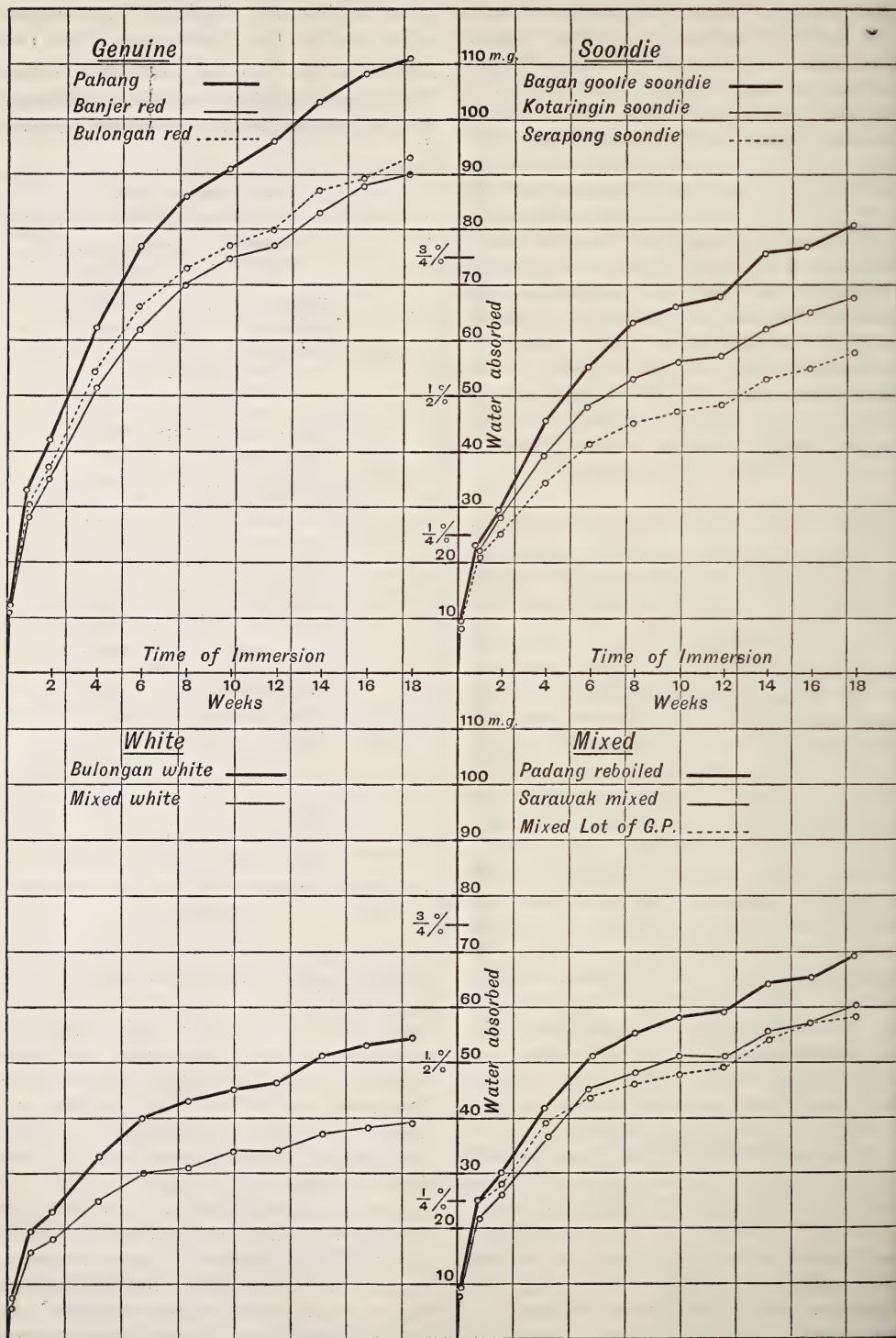
TABLE X.—SPECIFIC GRAVITY OF CLEANED GUTTA PERCHA
(2.2 m./m. SHEET AT 15°C .)

	Description of Material.	Spec. grav.	Ratio $\frac{G}{R}$.
I. Genuine.	Pahang	0.9858	3.9
	Banjer red	0.9868	4.0
	Bulongan red.....	0.9911	3.4
	Mean.....	0.9879	3.8
II. Soondie.	Bagan	0.9709	1.44
	Kotaringin*	0.9729	1.30
	Serapong.....	0.9767	1.38
	Mean.....	0.9735	1.37
III. White.	Bulongan white	1.0093	1.57
	Mixed white	1.0186	1.14
	Padang white.....	0.9911	1.40
	Mean.....	1.0063	1.37
IV. Mixed.	Padang reboiled	0.9960	1.18
	Sarawak mixed	0.9912	1.20
	Mixed after cleaning	1.0022	1.75
	Mean.....	0.9965	1.38
V. Various.	Balata.....	0.9731	1.16
	G.P. from leaves.....	0.9625	5.19
	Para-caoutchouc.....	0.9275	—

* Goolie red.

The same description of sheets was used for determining the absorption of water after prolonged immersion, the experiment extending over 18 weeks. The area of each strip exposed to the water was approximately one square decimeter, and its weight about 10 grams. The results are plotted in diagram No. 44, in which the materials are again divided into the four groups for better comparison, the actual figures appearing in the Appendix. As will be observed, the materials belonging to each group behave much alike, which shows that there is really a kind of relationship between them, and we shall find this similarity between the members of each group in other respects also. The smoothed mean curves for each group, directly deduced from observation, are shown in Fig. 45 on the left, and the corresponding

FIG. 44.



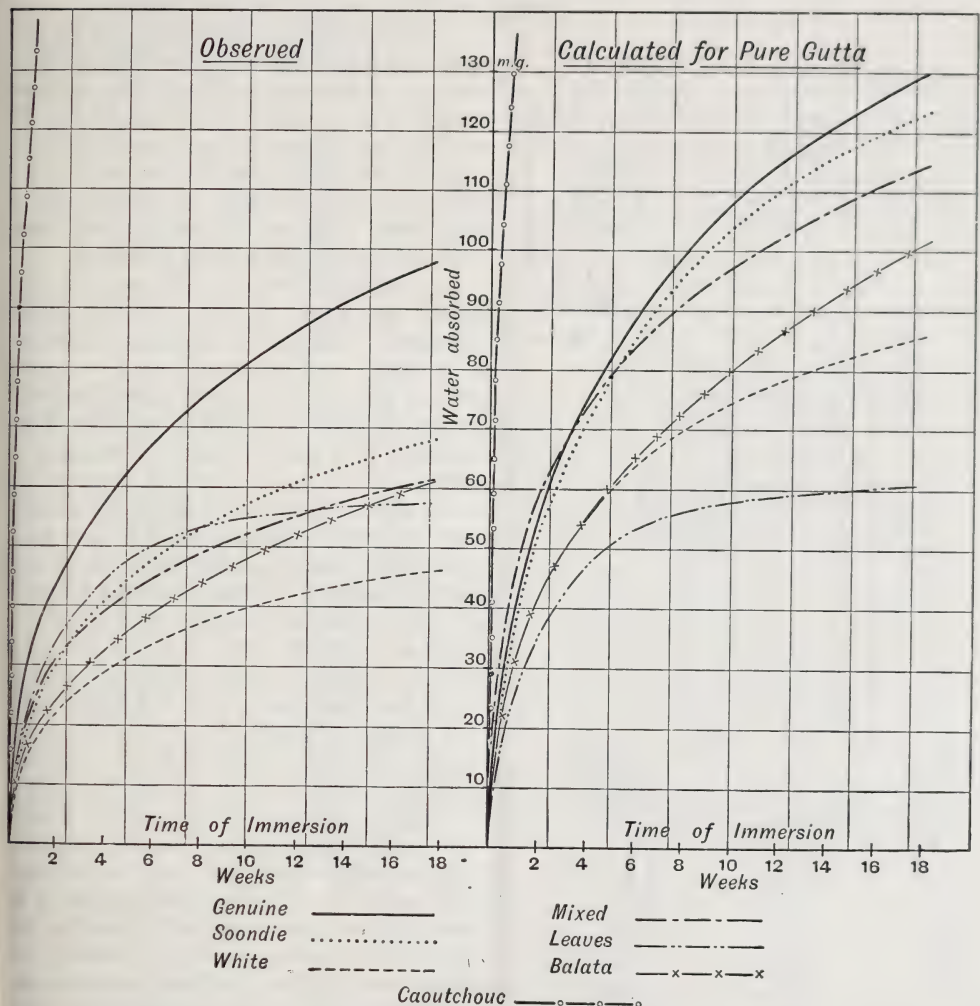
ABSORPTION OF WATER BY DIFFERENT BRANDS OF GUTTA PERCHA.

Thickness of sheet, 2.2 m/m.; area, 1 sq. dm.; weight, 10 g.

values, reduced to "pure gutta," on the right. The reduction to pure gutta is based on the assumption that it is the hydrocarbon which chiefly absorbs the water,¹ the resin being practically impervious to it. It is interesting to observe that after reduction to pure gutta, the best kinds of material are the most pervious,

as is well known, a very much greater absorptive power for water than gutta percha, and this is still the case after reduction to pure gutta, as the curves show. Similar experiments, in which sea water was used in place of the water from the Kent Water Company, gave very curious

FIG. 45.



ABSORPTION OF WATER BY DIFFERENT CLASSES OF GUTTA PERCHA.
Thickness of sheet, 2.2 m/m. ; area, 1 sq. dm. ; weight, 10 g.

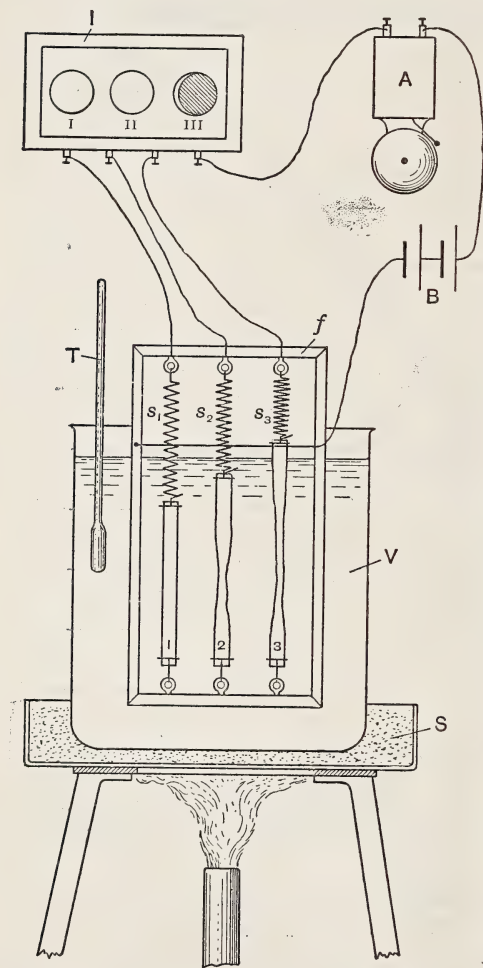
and the gutta percha from leaves the least; whereas if the materials be directly compared with each other, the "white" sorts show the least absorption. Pure Para-caoutchouc shows,

results, to which I shall refer on another occasion. Another physical property of gutta percha, which is of some practical importance, is the *softening temperature*, which depends almost entirely upon the relative proportion of gutta and resin, as I should like to demonstrate to you by an experiment.

¹ As the materials all contain over 1 per cent. of water before immersion, the dirt contained in them must have been completely saturated beforehand, so that practically no further absorption of water by it can take place.

I have here a little apparatus (Fig. 46) consisting of a rectangular frame, in which three strips (1, 2, and 3) of gutta percha are each held under the tension of a spring, it being so arranged that an electric contact is established and an alarm sounded as soon as one of the strips becomes soft enough to allow the spring to pull it apart. The three materials contain $2\frac{1}{2}$, 38 and 60 per cent. of resin re-

FIG. 46.



SOFTENING TEMPERATURE OF GUTTA PERCHA.

spectively, the one with the low percentage having been artificially produced. The frame with the strips is immersed in water contained in a large beaker, which is being slowly heated on a sand bath. The temperature of the water is now about 40°C . and nothing has yet occurred. On reaching 42°C . the bell sounds for the first time and shutter No. 3 of the indicator drops, which shows that the

material containing 60 per cent. of resin has sufficiently softened to give way to the spring;—now the bell rings a second time and shutter No. 2 drops. I find the temperature of the water to be 48°C . A rather long time elapses before the bell rings a third time and No. 1 shutter drops;—however, you hear it now and the temperature at which the strip with $2\frac{1}{2}$ per cent. of resin softens I find to be about 55°C .¹

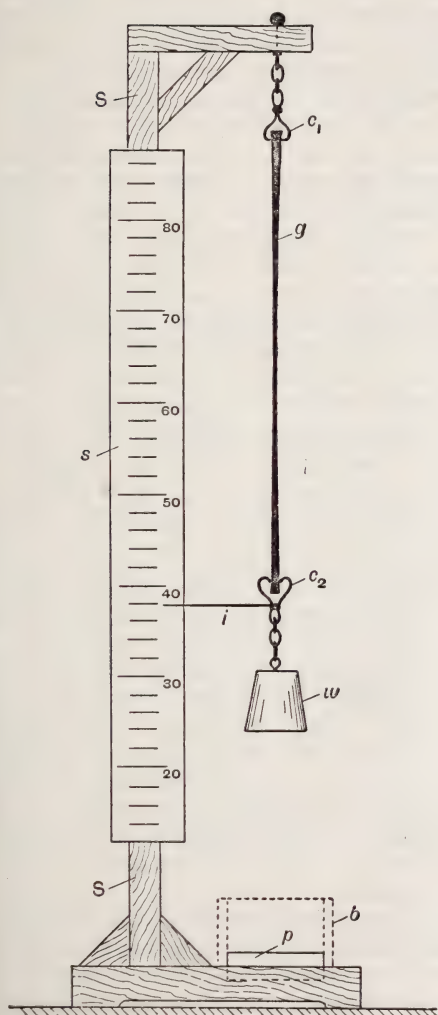
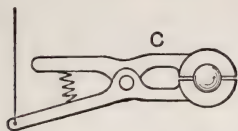
A third physical property, viz. the time required by a material to become hard again on cooling, after having previously been softened in hot water, also depends chiefly on the relative percentage of gutta and resin, as you will see from some Tables to be given later on; but time will not permit me to enter more fully into the subject, and I must now consider the *mechanical* properties.

The principal mechanical property with which we have to deal is the *tensile strength*. When gutta percha is stretched it becomes much stronger, as you observe when I pull this thin strip apart by hand. At first it gives way easily; but after it has stretched to a certain extent, it becomes so strong that I cannot further lengthen it. I can show you this more distinctly with the large apparatus (Fig. 47) which I have here. You observe the thin rod of gutta percha with the thickened ends, technically called a "gut," suspended from the bracket at the top. I apply a weight of 4 lbs. to it and you see it stretches at once to a certain point on the scale, but it does not break, even if I apply twice that weight, although the gut has become considerably thinner than at first. To accelerate matters, I now load it with 21 lbs., it stretches still further and now breaks. If the experiment had been carefully made, and the breaking strain per square inch of *original area* taken, as is usual, it would have worked out to be something between 2,000 and 3,000 lbs. for that particular material; but, if instead of the original area, the *final sectional area* at breaking had been taken, the strain would have been found to be about 12,000 lbs. per square inch. I have other guts here made of materials having different percentages of resin. If I were to test them in the same way, you would see that their tensile strength depended largely on these percentages. Here, for instance, is a material having about 45 per cent. of gutta

¹ These figures are only of relative value, depending on the conditions of the experiment. They are not comparable with those given in the Tables which follow; this also applies to other figures obtained during the lecture.

and 55 per cent. of resin, which breaks at about 770 lbs. to the square inch; here is another gut of the same material, after most of the resin has been extracted with petroleum spirit, and for this nearly twice that breaking strain would be required.

FIG. 47.



APPARATUS FOR TESTING GOLF BALLS.

Shown in use for Stretching Test.

The *elongation*, i.e. the extent to which a gut stretches before it breaks, is also greatly

affected by the percentage of resin, being in the last two cases, for instance, 460 and 500 per cent. respectively, but it also depends on the nature of the gutta.

There are also other properties, such as the degree of hardness at ordinary temperatures, the resistance to pressure, or to a blow, or to shearing, which are all greatly affected by the percentage of resin; however, I can only call attention to these in passing and we must now consider the more important

ELECTRICAL PROPERTIES.

These depend chiefly on the nature of the gutta and to a lesser extent on that of the resin; but only very slightly, on the relative proportion of these two components. They also depend upon the nature and amount of the impurities, and on the water. We shall see later on, that the electrical properties, i.e. the insulation resistance and inductive capacity, are very little affected by the extraction of the resin, unlike the physical and mechanical properties.

The insulating property of gutta percha was first observed, as far as I know, by Dr. Werner von Siemens in the year 1846. Faraday also noticed this property somewhat later, and recommended gutta percha for insulating purposes in March, 1848.¹

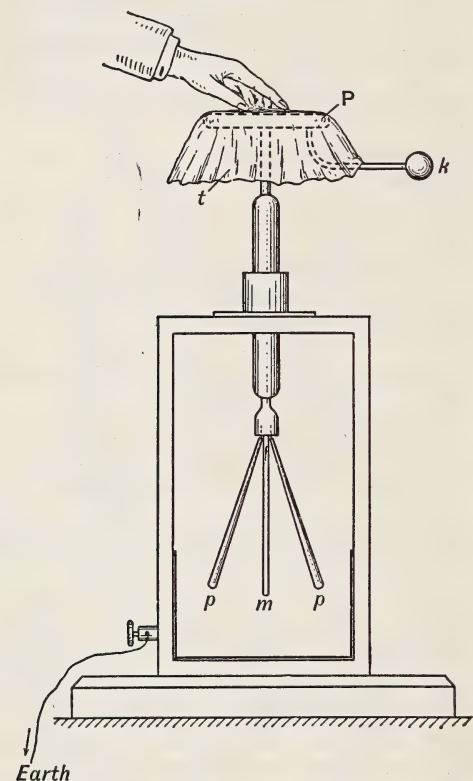
I should like to show you the two principal electrical qualities of gutta percha by an experiment. I have here an electroscope (Fig. 48), with a flat brass disc at the top, and below it two pith rods suspended on either side of a fixed strip of brass, which throw their shadow on to a screen in front of the instrument. I spread a thin piece of gutta percha tissue over the brass disc like a table-cloth, and now charge the electroscope by means of the brass knob at the side. You observe the pith rods diverge and now remain stationary. I lay my fingers on the top of the disc, so that they are separated from it by the tissue, and you observe the rods slightly converge and then remain stationary. On withdrawing my hand they again take up their former position. Now, this simple experiment demonstrates two electrical properties of gutta percha at the same time. The fact that I could hold my hand, which through my body was connected to earth, on the other side of the thin tissue for a considerable time, without discharging the electroscope, shows its excellent insulating quality; and the binding of the electrical charge of the disc of the electro-

¹ *Phil. Mag.*, 1848, vol. 32, p. 165.*

scope, indicated by the temporary partial collapse of the pith rods, whilst my hand rested on the tissue, showed the inductive capacity of the material. The insulation should be as high as possible and the inductive capacity, for most purposes, as low as possible; but whereas the latter is mostly associated with other good qualities of the material, such is not always the case with a high insulation.

Faraday, it appears, had some difficulty in 1848 in obtaining gutta percha with a sufficiently good insulation for his purposes;

FIG. 48.



INSULATION AND ELECTROSTATIC CAPACITY OF GUTTA PERCHA.

but he found that this was due to an excessive amount of water contained in the commercial material. This is rather an important matter, and I should therefore like to show you some experiments on the effect of water in gutta percha on its insulating property. I have here some strips containing about 15 per cent., 10 per cent., 5 per cent., and $2\frac{1}{2}$ per cent. respectively, and I charge the electroscope again, as you see from the divergence of the pith rods. I now touch the brass knob with the strip containing 15 per cent. of water,

pressing my finger against the other side of the same, and you observe the pith rods gradually converge; but as they do not regain their former position when I remove the strip it shows that the charge has been dissipated by the contact with the strip. I repeat the experiment with the next strip containing 10 per cent., and you observe how much more slowly the charge disappears. I take the one with 5 per cent. and find it to be a good insulator, in fact, practically equal to that containing $2\frac{1}{2}$ per cent. water; but I must mention that different kinds of gutta percha behave differently in that respect. We shall recur to the influence of water on the electrical properties presently, when I shall give you some exact figures; but I should first like to call your attention to Table XI., which gives the specific insulation and inductive capacity of various specimens of gutta percha¹ in comparison with other materials, such as paraffin wax, colophony, ebonite, &c., known to be good electrical insulators. I also give these particulars for an average sample of the resin extracted from gutta percha by means of petroleum spirit. The insulation in Megohms at 75° F. is given per cube knot of the material and also per knot of a cylindrical layer or tube, whose outside diameter, D , and inside diameter, d , are in the ratio 10:1, so that $\text{Log. } \frac{D}{d} = 1$, which is a convenient way of expressing it for the cable manufacturer. The specific inductive capacity in Microfarads is also given per cube knot and for a tube with $\text{Log. } \frac{D}{d} = 1$, it is also compared with that of air as a standard, the usual way of expressing specific inductive capacity in text-books.

The figures show how greatly these electrical data vary for different specimens of gutta percha. Take, for instance, the insulation per cube knot, which is only 382 Megohms in the case of the lowest material, otherwise of very good description, and as much as 139,300 Megohms, *i.e.* 365 times the former amount, in the case of the highest, otherwise inferior material.

As regards the gutta percha from leaves, Lord Kelvin and Dr. Hopkinson found a higher insulation for Sérullas' material than we ourselves obtained for mine; but we have also occasionally observed equally high insulations

¹ The electrical and mechanical tests were, if not otherwise stated, all made in the Core Testing Department of Messrs. Siemens Brothers & Co.'s works at Woolwich, under the superintendence of Mr. Paul Estler.

TABLE XI.—ELECTRICAL PROPERTIES OF GUTTA PERCHA AND SOME OTHER MATERIALS.

Description of Material.	Insulation Resistance (Megohms).			Inductive Capacity (Microfarads).			
	Per cube knot.	Per knot ($\log \frac{D}{d} = 1$.)	Source.	Air = 1.	Per cube knot.	Per knot ($\log \frac{D}{d} = 1$.)	Source.
GUTTA PERCHA :							
Cleaned commercial, highest	139,300	51,050	(1)	4'496	0'0801	0'2184	(1)
" " lowest	382	140	(1)	2'619	0'0466	0'1272	(1)
From leaves, Sérullas'	57,980	21,260	(2)	2'950	0'0525	0'1433	(2)
" " "	120,700	44,260	(3)	3'120	0'0555	0'1515	(3)
" " Obach's	48,630	17,830	(1)	2'707	0'0482	0'1315	(1)
Willoughby Smith's	955	350	(4)	3'122	0'0556	0'1515	(4)
BALATA	2,145	786	(1)	2'724	0'0485	0'1323	(1)
CAOUTCHOUC :							
Pure vulcanised	130,000	47,660	(1)	2'652	0'0474	0'1293	(1)
Mixed vulcanised	81,700	29,950	(1)	3'405	0'0606	0'1654	(1)
Pure unvulcanised	15,440	5,659	(1)	2'505	0'0446	0'1217	(1)
Submarine cable	—	—		3'561	0'0634	0'1730	(1)
Overland telegraph cable	—	—		3'405	0'0606	0'1654	(1)
EBONITE	16,540	6,061	(1)	3'160	0'0562	0'1534	(6)
PARAFFIN WAX	34,230	12,550	(1)	2'310	0'0411	0'1122	(6)
SULPHUR	21,180	7,764	(5)	3'825	0'0681	0'1858	(6)
RESIN :							
Colophony	21,700	7,952	(1)	2'550	0'0454	0'1239	(6)
Extracted from gutta percha	14,360	5,264	(1)	3'270	0'0582	0'1587	(1)
WATER	—	—		75'700	1'3480	3'6770	(7)

(1) Our own determinations.

(2) Lord Kelvin's Report to the Gutta Percha Corporation.

(3) Dr. Hopkinson's Report to the Gutta Percha Corporation.

(4) Clark and Sabine's "Electrical Tables and Formulæ."

(5) Fousscreau (1888) tested at 69° C.

(6) Boltzmann.

(7) E. B. Rosa.

in gutta percha extracted from leaves by my process. Paraffin wax, colophony, ebonite, &c., are intermediate between the maximum and minimum found for gutta percha; but pure vulcanized caoutchouc has a very high insulation, approaching the maximum observed for gutta percha. The specific inductive capacity also shows notable variations, the lowest figure per cube knot being '0466 and the highest '0801. In this respect the gutta obtained from leaves by extraction with petroleum spirit compares favourably with that of the best sorts of ordinary gutta percha. Pure vulcanized caoutchouc lies between the lowest figure and that of the gutta from leaves, viz. '0474 Microfarad. Paraffin wax, a hydrocarbon like pure gutta and caoutchouc, has the lowest inductive capacity of all the materials recorded in Table XI., viz. '0411; water, on the other hand, has the highest known of any substance, i.e. 1'348 Microfarad per cube knot. The significance of this will be seen on consideration of Table XII., which gives the insulation and

inductive capacity of several brands of gutta percha each with a high and a low percentage of water. The decrease of insulating power with higher percentages of water is unmistakable; although, perhaps, it is not so great as one might expect. On the other hand, the effect of a larger percentage of water on the inductive capacity is very marked, particularly in the case of "Banjer white," and Bulongan white, but also in "Pahang" and "Bagan."

A third electrical property, which has recently come into prominence, is what is called the *dielectric strength* or resistance to piercing by high voltages. Table XIII. gives the dielectric strength of various gutta percha-covered wires (cores), and the corresponding thickness of the insulating material or *dielectric*; it also gives for comparison the dielectric strength of caoutchouc-covered wires and of ebonite. You observe that a thickness of a little over $\frac{1}{8}$ inch of gutta percha breaks down with 40,000 volts, and one of about $\frac{1}{10}$ inch with 28,000 volts.

TABLE XII.—INSULATION (MEG OHMS) AND INDUCTION (MICROFARADS) PER CUBE KNOT, WITH LOW AND HIGH PERCENTAGES OF WATER.

° Water.	Genuine.			Soondie.			White.			Mixed and Reboiled.														
	Pahang.		Banjer red.		Bagan.			Kotaringin (Goolie red).		Banjer white.			Bulungan white.			Sarawak mixed.		Banca reboiled.						
	° Water.	Insulation.	Induction.	° Water.	Insulation.	Induction.	° Water.	Insulation.	Induction.	° Water.	Insulation.	Induction.	° Water.	Insulation.	Induction.	° Water.	Insulation.	Induction.						
Low	1'5	6,173	'0523	1'4	6,427	'0560	1'7	7,950	'0521	0'8	7,730	'0530	0'6	10,410	'0555	0'9	57,910	'0575	1'1	24,250	'0564	1'0	82,320	'0648
High	6'3	5,480	'0675	5'2	5,625	'0592	7'3	4,350	'0682	7'2	6,080	'0662	7'1	6,454	'0698	11'2	39,030	'0809	7'0	24,250	'0718	10'0	68,020	'0753

TABLE XIII.—DIELECTRIC STRENGTH OF GUTTA PERCHA IN COMPARISON WITH OTHER MATERIALS.

Description of Dielectric.		Thick- ness of Di- electric. Inches.	Voltage at which Dielectric broke down. ¹
GUTTA PERCHA :			
Cores of various sizes, from sub- marine cables...	Copper per knot.	G.P. per knot.	
	500 lbs.	320 lbs.	0'127 40,000
	450 "	280 "	0'109 28,000
	107 "	150 "	0'0925 18,000
	107 "	130 "	0'0825 15,000
	130 "	130 "	0'0805 14,000
Test-cores made from	Pahang		0'051 19,000
	Banjer red		0'058 20,000
	Bulungan red		0'048 19,000
	Bagan soondie		0'049 15,000
	Serapong soondie ...		0'054 18,000
	G.P. from Leaves....		0'047 17,000
CAOUTCHOUC :			
Core of Overland Telegraph Cable.....		0'102	20,000
Core of Submarine Cable		0'078	19,000
EBONITE.....		0'130	38,000

¹ A comparatively low voltage was first applied ; this was raised by 1,000 volts about every ten minutes, until the dielectric broke down.

Table XIV. gives the chemical composition and the physical, mechanical, and electrical properties for the different grades of each of the twelve brands of gutta percha with which we have become acquainted, each row of figures being the average of the results obtained from a certain number of individual lots, as stated in the Table. The figures here given are most interesting and instructive, and clearly show how largely the physical and mechanical properties of gutta percha depend upon its chemical composition, *i.e.* the relative proportion of gutta and resin, or ratio $\frac{G}{R}$. It almost looks as if the specific insulation and induction also followed this rule, inasmuch as both mostly increase with an increasing amount of resin ; but, as I have pointed out before, this connection is only an apparent one, the electrical properties being in reality only slightly affected by the removal of the resin, whereas the physical and mechanical properties are entirely changed thereby.

The two temperatures given in the Table, viz. that at which the respective material softens and that at which it becomes pliable, have merely a relative value, and only hold good for the particular method of testing here

TABLE XIV.

CHEMICAL COMPOSITION, PHYSICAL, MECHANICAL, AND ELECTRICAL PROPERTIES OF VARIOUS BRANDS
OF GUTTA PERCHA.

Description of material.				Percentage composition.					Quality.	Physical properties.			Mechanical properties.		Electrical properties (per cube knot.)		
Group.	Name of brand.	Grade.	No. of Lots tested.	Gutta	Resin.	Dirt.	Water	Ratio	$\left(\frac{r}{10}\right)$ Q.	Temperature when		Time hardening.	Tensile strength	Elongation.	Insulation. 75° F. 2nd min.	Inductive capacity.	
				G.	R.	D.	W.	G R		com- mencing to soften	pliable.						
				p.c.	p.c.	p.c.	p.c.			° C.	° C.	Mins.	lbs. per sq. in.	percent.	Meg- ohms.	Micro- farad.	
1.—GENUINE.	Pahang ...	I.	19	80.0	17.7	1.4	0.9	4.52	1c	48.8	66.1	2½	5,067	444	1,077	.0511	
		II.	9	77.8	19.0	1.8	1.4	4.10	2	48.3	64.4	4	4,138	414	2,662	.0559	
		III.	12	74.8	22.0	1.5	1.7	3.41	2a	45.5	65.5	3½	3,940	410	4,326	.0558	
	Average			40	78.1	19.2	1.5	1.2	4.08	2	47.7	65.5	3½	4,577	427	2,408	.0535
	Banjer red	I.	27	70.5	26.9	1.4	1.2	2.62	2b	45.0	67.2	5	4,123	417	3,723	.0542	
		II.	22	67.5	29.6	1.5	1.4	2.28	3	44.4	65.5	5	3,546	377	6,113	.0559	
		III.	21	62.0	35.0	1.0	1.4	1.77	3c	42.2	65.0	11	2,932	384	10,150	.0580	
	Average			70	67.0	30.2	1.5	1.3	2.22	3	43.8	66.1	6½	3,584	394	6,400	.0559
	Bulongan red	I.	10	73.4	24.2	1.4	1.0	3.03	2c	46.1	64.4	4	4,200	440	4,511	.0537	
		II.	7	67.7	29.8	1.4	1.1	2.27	3	45.5	62.7	7	3,400	415	5,292	.0554	
		III.	5	60.3	37.4	1.3	1.0	1.61	3b	43.8	62.2	15½	2,494	383	17,200	.0579	
	Average			22	68.6	29.0	1.4	1.0	2.37	3	45.5	63.3	8	3,557	419	7,643	.0552
2.—SOONIE.	Bagan	I.	13	57.7	40.6	1.0	0.7	1.42	4a	40.0	61.6	9	2,528	383	10,800	.0523	
		II.	8	57.0	41.3	1.1	0.6	1.38	4a	39.4	61.6	10½	2,274	373	5,357	.0525	
	Average			21	57.5	40.9	1.0	0.6	1.40	4a	40.0	61.6	9½	2,431	379	5,728	.0524
	Kotar- ingin	I.	18	57.8	40.3	1.2	0.7	1.43	4	40.0	61.1	12	2,443	383	3,284	.0541	
		II.	17	55.6	42.7	1.0	0.7	1.30	4a	39.4	61.1	17½	2,088	367	2,859	.0558	
		III.	13	51.3	46.2	1.6	0.9	1.11	4c	38.3	59.4	34	1,654	365	5,524	.0604	
	Average			48	55.2	42.9	1.2	0.7	1.29	4a	39.4	60.5	20	2,094	372	3,739	.0563
	Serapong	I.	18	57.5	41.0	1.0	0.5	1.40	4a	41.1	60.5	12	2,466	390	35,180	.0536	
		II.	13	54.4	44.4	0.7	0.5	1.23	4b	40.0	60.5	20	2,239	392	31,340	.0540	
	Average			31	56.2	42.4	0.9	0.5	1.33	4a	40.5	60.5	15½	2,371	391	33,590	.0537
3.—WHITE.	Bulongan	I.	4	52.5	45.0	1.5	1.0	1.16	4b	41.6	70.0	18	2,537	420	46,330	.0581	
		II.	3	51.7	45.9	1.5	0.9	1.13	4c	40.0	65.5	31	2,392	433	41,330	.0555	
	Average			7	52.2	45.4	1.5	0.9	1.15	4c	41.1	67.7	23½	2,474	426	44,220	.0570
	Mixed	I.	3	52.0	46.0	1.2	0.8	1.13	4c	42.7	78.8	19	3,180	418	86,550	.0541	
		II.	5	48.5	48.3	0.9	2.3	1.00	5	42.7	74.4	23	2,169	332	50,520	.0644	
		III.															
	Average			8	49.8	47.4	1.1	1.7	1.05	5	42.7	76.1	21½	2,548	364	67,800	.0606
	Banjer	I.	7	53.6	42.9	1.7	1.8	1.25	4b	43.3	75.0	24	3,026	406	45,780	.0612	
		II.	2	45.3	48.2	2.2	4.3	0.94	5a	39.4	67.7	44	2,430	418	64,500	.0662	
	Average			9	51.8	44.1	1.8	2.3	1.17	4b	42.2	73.3	28½	2,894	409	50,060	.0624
4.—MIXED AND REBOILED.	Sarawak mixed	I.	17	61.3	35.1	2.0	1.6	1.75	3c	42.7	65.0	12	2,572	397	12,330	.0602	
		II.	37	55.7	40.9	1.7	1.7	1.36	4a	39.4	61.6	22	2,301	378	15,410	.0617	
		III.	26	51.7	44.8	1.8	1.7	1.16	4c	38.8	61.6	44	1,689	383	22,470	.0627	
	Average			80	55.6	40.9	1.8	1.7	1.36	4a	40.0	62.7	27	2,160	384	17,060	.0618
	Padang reboiled	I.	2	50.3	45.7	1.5	2.5	1.10	4c	36.6	61.6	63	1,465	475	16,840	.0649	
		II.	3	50.2	46.0	2.3	1.5	1.09	4c	39.4	63.8	55	2,177	427	92,980	.0589	
		III.															
	Average			5	50.3	45.8	2.0	1.9	1.10	4c	38.3	62.7	58	1,892	446	62,520	.0613
	Banca reboiled	I.	4	47.1	50.5	1.3	1.1	0.93	5a	38.8	63.3	54	1,552	371	71,380	.0577	
		II.	2	46.0	52.4	0.8	0.8	0.88	5a	40.5	62.2	80	1,809	428	16,870	.0559	
	Average			6	46.8	51.1	1.1	1.0	0.92	5a	39.4	62.7	63	1,638	390	46,750	.0571

employed. The softening-temperature is determined as follows:—A thin plate of the gutta percha to be tested is placed in a large shallow water bath, which is slowly heated over a gas burner. A rather long lever is supported at one end by a pivot, and carries a 1-lb. weight at the other. Half-way along the under side of the lever is fixed a vertical stud of 3 mm. diameter, and under this stud the gutta percha-plate is placed from time to time to see whether any permanent impression is produced. As soon as this is the case, the temperature of the surrounding water is read off and recorded as that at which the material “commences to soften.” The temperature at which the material “becomes pliable” is obtained in a somewhat similar way to that which I showed you a little while ago. A strip of the material to be tested, about 70 mm. long, 25 mm. wide and 2 mm. thick, is held vertically in a tall water bath, the upper end is provided with a clip, and to this a thin cord is fixed, which passes over a pulley and carries a $\frac{1}{2}$ -oz. weight at the other end. A definite pull being thus exerted on the strip, the temperature is observed at which this pull is just sufficient to tear it asunder. The “time of hardening” is that taken by the material to become sufficiently rigid to resist the pressure of the stud in the apparatus used for the softening-temperature; but filled with water kept exactly at 75° F. the material, which is in the form of a 2 mm. plate, having previously been heated to the temperature at which it becomes pliable. The time of hardening is, as the Table shows, greatly affected by the amount of resin in the material, and I have found that its variation with the percentage of resin can, with certain restrictions, be represented by a continuous curve.

APPLICATION OF GUTTA PERCHA TO VARIOUS PURPOSES.

At the beginning of this lecture I mentioned that Charles Hancock was the pioneer of the practical applications of gutta percha, and I will now add that his first patent (No. 10,185 O.L.), was dated May 15th, 1844, and entitled *Certain Improvements in Cork and other Stoppers and a new Composition or Substance which may be used as a substitute for, and in preference to, Cork, and a Method or Methods of Manufacturing the said new Composition or Substance into Bungs, Stoppers, and other useful Articles*. Hancock proposes to mix gutta percha in the plastic state, or a combination of gutta percha and

caoutchouc with powdered cork, or with wood sawdust, in a masticator, and to press the composition into moulds for further use. He also proposes to use a solution of gutta percha or caoutchouc, or a mixture of glue and treacle, for the same purpose.

The Editor of the *Mechanics' Magazine*, Mr. J. C. Robertson, evidently took a great interest in the matter, and regularly published abstracts of the various “Gutta Percha Patents” in his Journal, giving them consecutive numbers;¹ but curiously enough he called Brooman’s specification (No. 10,550 O.L.), of March 11th, 1845, “No. 1,” and described it as a *master patent*, Hancock’s prior patent being entirely ignored. The explanation of this appears to be that Charles Hancock himself was the inventor of the subject-matter of Brooman’s specification, and his first patent was evidently considered a *weak* one. It was, therefore, to Hancock’s own interest that nothing further should be said about it, after he had obtained the second and stronger patent through Mr. Brooman. In this respect it is perhaps of interest to mention that the last-named gentleman and Mr. Robertson had the same business address, and were, I believe, related to each other, so that the omission of Hancock’s original patent was no doubt made with his consent, and not against his wish, as one might be inclined to think. On June 6th, 1851, Mr. Hancock filed a *disclaimer* to his first patent, in which all parts referring to the use of caoutchouc alone, of glue and treacle, and of gutta percha in its native fluid state in combination with powdered cork or with wood sawdust, were disclaimed.

Brooman’s patent (No. 10,550), the first of the “Gutta Percha Patents” enumerated in the *Mechanics' Magazine*, is really a most comprehensive one, in spite of its modest title, according to which it purports to deal only with the application of gutta percha to the manufacture of *artificial fuel, mastics and cements*. We became acquainted with the machines for washing and kneading gutta percha described in this patent, in our last lecture, and I should now like to refer to some of the other proposals made therein. Brooman suggests the use of gutta percha for artificial fuel, mixed with small coal and coal-tar pitch. I need hardly tell you that such an application is entirely out of the question at the present time, but the resin extracted from the inferior kinds of this

¹ *The Mech. Mag.*, 1846, vol. 44, pp. 222*, 238*, 253*, 269*, 319*; vol. 45, p. 138*.

substance by the hardening process is, I believe, used for some such purpose. I myself made a number of experiments with this resin years ago, but failed to obtain really satisfactory results, on account of its low melting point and the smoke it produced during combustion.

Brooman further proposes to mix gutta percha with various other ingredients for different purposes, for instance with caoutchouc, as was already suggested in Hancock's first patent. I have such mixtures here which I prepared fully twenty years ago, and you see they are still in a very fair state of preservation. Mixtures of this kind may be useful for some special purposes, where a somewhat greater degree of elasticity is required than that possessed by gutta percha alone. Other substances recommended by Brooman for admixture with gutta percha are sulphur, pigments, French chalk, emery, and sand; French chalk rendering it smooth and emery making it abrasive, as these specimens show which I have brought with me. Brooman proposes to use some of the mixtures for making picture frames, cornices, mouldings and other architectural ornaments, for panels, mosaics, buttons, studs, and a variety of other things. He also proposes the use of gutta percha for parts of machinery, such as valves, belting, &c., and describes an arrangement for applying it in the plastic state to cotton, wool, and other textile materials to render them waterproof, and suitable for table-covers, floor-cloths, tarpaulins, and so on.

Many of these articles are exhibited here to-night, and I should like to call your attention particularly to the beautiful exhibits from the Gutta Percha Company¹ in the centre of the table, where you will see some exceedingly fine work in gutta percha. Most of these exhibits are very old, some of them having been manufactured as early as 1846, and being therefore over 50 years old; these were shown at the Great Exhibition of 1851. There are also some interesting documents here, which refer to the early importation of gutta percha. Other objects made for the 1851 Exhibition by the Gutta Percha Company are lent by the Kew authorities, and you will no doubt remember the collection of articles made by natives, which was shown in the first lecture (*vide* Fig. 13, *ante*).

Messrs. R. and J. Dick, of Glasgow, exhibit specimens of their present manufactures such as

boot soles, horse pads, pump buckets, hydraulic rings, driving belts, acid bottles, &c.

Another patent (No. 10,582) was taken out by Brooman about a fortnight later, viz. on March 27th, 1845, which is probably also to be ascribed to Charles Hancock, although I cannot with certainty say so. Its title is:—*A thread made from a substance not hitherto applied to that purpose, and also the application of it to the manufacture of piece goods, ribbons, paper, and other articles.* In this specification a machine is described for cutting sheets into threads by rotating circular knives, and for pressing gutta percha through a die box, allowing the threads to harden in cold water. I have here some thin gutta percha cord, prepared about seven years ago, but in a different way, viz. by stretching, and you observe its excellent state of preservation.

On May 20th, 1845, Christopher Nickels of London¹, took out a patent (No. 10,673) for *Improvements in the binding of books, etc.* He proposed to use a solution of gutta percha, in place of paste or glue, and also as a "vehicle for colours" in colouring the edges of books. He further proposed the use of sheets of gutta percha either alone or mixed with various substances as a suitable binding, in place of leather and cardboard.

Charles Keene, also of London, followed with patent (No. 10,692) taken out May 29th, 1845, and entitled *Improvements in Boots, Shoes, Gaiters, Overalls and other like Articles of Apparel.* His idea was to render the articles referred to waterproof, either by coating them with a solution of gutta percha, or by gutta percha applied in the plastic state, or by the introduction of thin layers of the material, as, for instance, between the outer and inner soles of boots. He also proposed to manufacture the above articles of gutta percha mixed with various other substances, *e.g.* leather, hair, cotton-wool, caoutchouc. The various parts of articles so made could be united by passing a hot iron over the joint, thus obviating the necessity of sewing.

The next patent (No. 10,825) was taken out by Henry Bewley, on September 4th, 1845, for *Certain Improvements in flexible Syringes, Tubes, Bottles, Hose, and other like Vehicles and Vessels.* His proposal was to press gutta percha in the plastic state into moulds or to apply a solution of gutta percha in successive thin coats to a mould, until the

¹ This Company was founded by an Agreement between Bewley and Hancock, dated May 31st, 1845.

¹ *Vide* p. 99, *ante*.

required thickness was obtained. He also proposed to make tubes by forcing plastic gutta percha over a mandril and through a circular die.¹

Specimens of tubing and a collection of models of various gutta percha articles are exhibited by Messrs. H. Rost and Co., of Hamburg and Harburg.²

The patents just mentioned were the first six referring to gutta percha, and were all taken out before the end of 1845. In the course of the next three years Charles Hancock obtained six more patents in connection with gutta percha, viz. Nos. 11,032 and 11,208 in 1846, Nos. 11,575 and 11,874 in 1847, and Nos. 12,153 and 12,223 in 1848. Of these I mentioned three in my last lecture. Patents were also granted to Thomas Hancock and another in 1846 (No. 11,455), and in 1848 (No. 12,007); also to Thomas Forster in 1847 (No. 11,917), and to William Henry Barlow and Thomas Forster in 1848 (No. 12,136); to Anthony Lorimer in 1848 (No. 12,206), and to John Lewis Ricardo in 1848 (No. 12,262). These make a total of 18 patents taken out prior to 1849.

Perhaps the earliest practical use to which gutta percha was put was that for surgical appliances, Drs. Montgomerie and Oxley warmly recommending it for bandages, splints, receptacles for vaccine virus, &c. On his first furlough from India, Dr. Montgomerie brought the new substance to the notice of the principal makers of surgical instruments in London, but they all declined to have anything to do with it. He also suggested the use of gutta percha for stopping decayed teeth,³ and for this purpose it is still largely employed, as you know.

Gutta percha is sometimes used for ear-trumpets and also for the handles of surgical instruments, such as saws, knives, &c., as it affords a firm grip, and is preferable to wood for antiseptic reasons; but I am informed that it has to be hardened by vulcanisation for such purposes. It is employed by the medical profession in the form of very thin tissue, under the name of *gutta percha lamellata*; in the form of sticks after

special purification, as *gutta percha depurata*, and lastly in the form of a 10 per cent. solution in chloroform, under the name of *traumaticin*, as a substitute for collodion.

For chemical purposes, it is used in the form of tubes, pumps, syringes, funnels, bottles, &c., and I have some specimens of the latter, containing hydro-fluoric acid on the table.

For mechanical purposes, it is used as rings and cups for pumps, and hydraulic presses, driving bands, &c. For the latter purpose balata is also largely used, interposed between canvas; such belts can be joined by means of a solution of balata or gutta percha in carbon disulphide as I have it here in this bottle.

Another application of gutta percha is one which was shown in this very room in 1845 by the Secretary, Mr. Whishaw, viz. that for taking impressions from medals. I have prepared such impressions, which are in this small case, from three medals, namely the gold medal awarded to Dr. Montgomerie by the *Society of Arts* in 1845; the Queen's Jubilee medal of this year, and the Siemens and Halske Jubilee medal also of this year. In the same case you observe the galvano-plastic copper reproductions of the same. There is a small self-contained apparatus here on the table, in which the depositing process is going on at the present moment. Before starting the current it is necessary to rub the surface of the mould well with plumbago to make it conduct electrically.

There are also some beautiful gutta percha medals here, exhibited by the Gutta Percha Company, and some very old ones from the *Wew Museum*.

More ambitious impressions than those from medals are such as are taken from the interior of guns for inspection, and I have to thank the Director General of Ordnance Factories and Commander Chevallier, R.N., of the Royal Arsenal, Woolwich, for the interesting specimens which are exhibited to-night. Here you see some fine impressions in gutta percha, which show the action of cordite and of powder on the steel liners of guns. I have had a lantern slide prepared from a photograph of two such impressions, which I will now throw upon the screen. (Fig. 49.)

A. is from a 12" breach-loading gun after *Proof* and 99 full charges of *cordite* had been fired in it. You will observe that the rifling of the steel liner still appears in very good condition and hardly any erosion is noticeable.

¹ Bewley's machine for making tubes was adopted by the Gutta Percha Company being subsequently (1848), used in the covering of copper wire, and Mr. Willoughby Smith, the manager, informs me, that one of the men employed in building this machine at Messrs. Heseltines, Bow Bridge Iron Works, is still with him. Bewley's original machine is illustrated in the *Mechanics' Magazine*, 1846, vol. 44, p. 319.*

² Established 1848.

³ *Vide* letter to the Editor, *Mech. Mag.* 1846, vol. 45, p. 413*.

B. is from a 13.5" breach-loading gun after *Proof* and 158 full charges of *powder* had been fired in it. In this case you observe that the metal has been very badly attacked. The explanation of this is that cordite, during combustion, produces only gaseous products, which do not appreciably affect the steel liner of the gun; whereas powder, besides the gaseous products, produces also solid particles, which are driven in a fused state against the walls of the tube, thereby exerting a strongly erosive action on the metal.

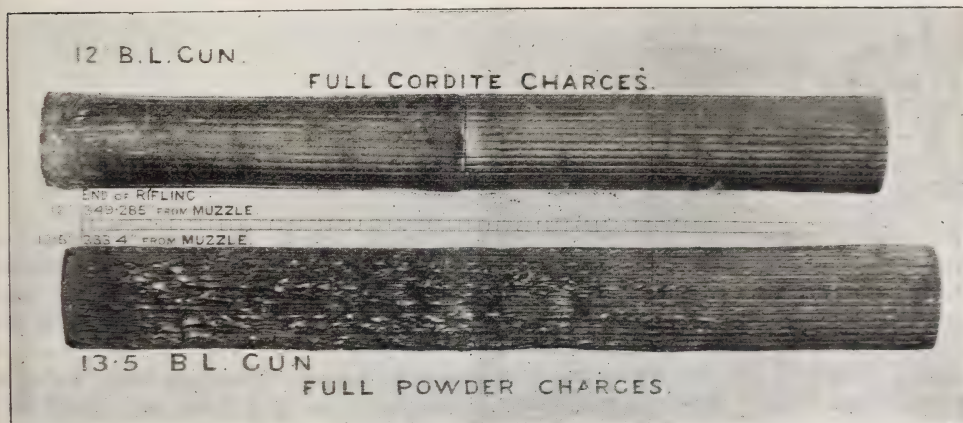
Here is an impression of part of the bore of a new gun, in which you can see all the tool marks, showing how very suitable gutta percha is for taking impressions of minute details, such as slight fissures and cracks.

gun tubes in gutta percha was introduced at the Royal Arsenal in 1856 by a Mr. McKinley; previously wax was used for the purpose.

The application of gutta percha to the insulation of submarine and subterranean cables, to which I shall now draw your attention, is undoubtedly by far the most important hitherto made of this substance. I have shown you by an experiment the excellent insulating property of gutta percha, and I have also given you the actual figures for comparing it with that of some other insulators.

I mentioned that Dr. Werner von Siemens first proposed the use of gutta percha for insulating purposes in 1846, and that in the following year he designed a screw-press for the seamless

FIG. 49.



GUN IMPRESSIONS.

For small guns and breach-loaders, the impression is taken by covering a long wooden stick with the soft plastic gutta percha, which is passed through the barrel. Wedge-shaped sticks are then driven in at both ends, so as to press the gutta percha against the inner wall of the gun tube. Here is a specimen of the stick that is used, and here an impression, which has been made in that way, showing the powder chamber and the rifling.¹ The practice of taking impressions of

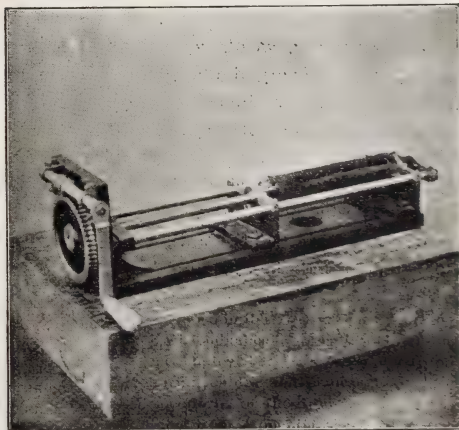
¹ The following impressions were lent by the Royal Arsenal, Woolwich, viz. :—

12-Pounder Breach Loading Gun, 6 cwt. (a) Gutta percha laid on stick ready for taking impression; (b) full length impression before firing.

4.7-inch Quick-firing Gun, with long chamber: (a) Before firing; (b) after 930 rounds of powder; (c) after 960 rounds of cordite.

6-inch Quick-firing Gun: (a) Chamber before firing; (b) bore after 135 rounds of powder and 329 rounds of cordite.

FIG. 50.



SIEMENS SCREW PRESS.

covering of wires with that material. This little machine is illustrated in Fig. 50; it is now in the Imperial Museum of Posts and Telegraphs at Berlin, where I saw it a year or two ago.¹ Early in 1848 it was used for the manufacture of some wire for a subterranean telegraph line $2\frac{1}{2}$ miles long, from Berlin to Gross Beeren, belonging to the Prussian Government.²

inductive capacity is also tested, and sometimes it is submitted to alternating currents of very high voltage. At Messrs. Siemens Bros. and Co.'s works, for instance, the core used for Atlantic cables is thus tested with over 5,000 volts.

Gutta percha cores which are intended to be used in deep water are, at these works, subjected to a great water pressure before being

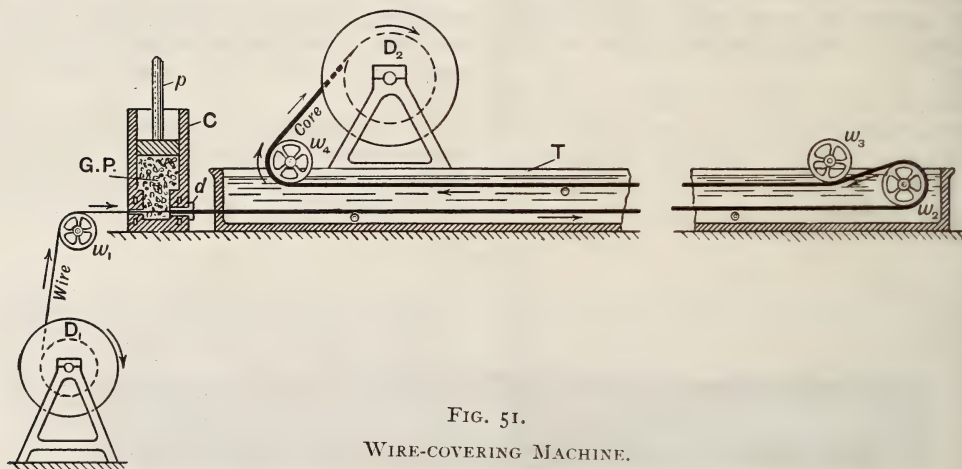


FIG. 51.

WIRE-COVERING MACHINE.

Fig. 51 illustrates the principle of the machinery used for covering wires with gutta percha. The wire, usually of copper, is wound on a reel or drum, D_1 , and from it passes through the lower part of a cylinder, C , provided with a piston, p , which is actuated by means of a screw and nut. Usually there are two cylinders used alternately, so as to provide a continuous supply of gutta percha to the wire. The gutta percha contained in the space between the piston and the bottom of the cylinder is forced through a die, d , where it surrounds the wire, which then enters a long trough with cold water, in which it passes to and fro several times, until the gutta percha has become sufficiently hard to admit of the covered wire being wound upon a drum, D_2 .

The gutta percha-covered wire is kept immersed in water and tested with a high battery power for electrical insulation at a standard temperature, usually 75° F. Its

electrically tested. The greatest depth of the North Atlantic Ocean is about 3,000 fathoms, and consequently the pressure of the water at the bottom is 530 atmospheres or $3\frac{1}{2}$ tons per square inch. The pressure used at Messrs. Siemens Bros. and Co.'s works for Atlantic cores is 4 tons per square inch, and the plant used for these tests is shown in Fig. 52. The gutta percha-covered wire is wound on to a drum, D , which is then lowered into a strong cylindrical tank, T , of compressed steel, which can be closed by a screw stopper, L , in the same way as is done with breach-loading guns. The large weight of the hydraulic accumulator, A , having been raised by means of the force-pump, P , communication between the accumulator and the tank is established by means of the pipes, p , and the pressure allowed to act on the core for 15 or 20 minutes, care being taken to allow all air to escape from the tank at the beginning of the operation. Any slight mechanical defect of the core, which would ordinarily elude detection, will by these means be made apparent during the subsequent electrical tests.

In order to give you an idea of the enormous pressure used for these tests, I will mention that in December, 1883, our steel tank broke

¹ The press was exhibited at the Paris Electrical Exhibition in 1881, together with some gutta percha-covered wire made with it. *Vide Report of the Jury, Annales Télégraphiques*, 1883 (3me série), vol. 10, p. 19.*

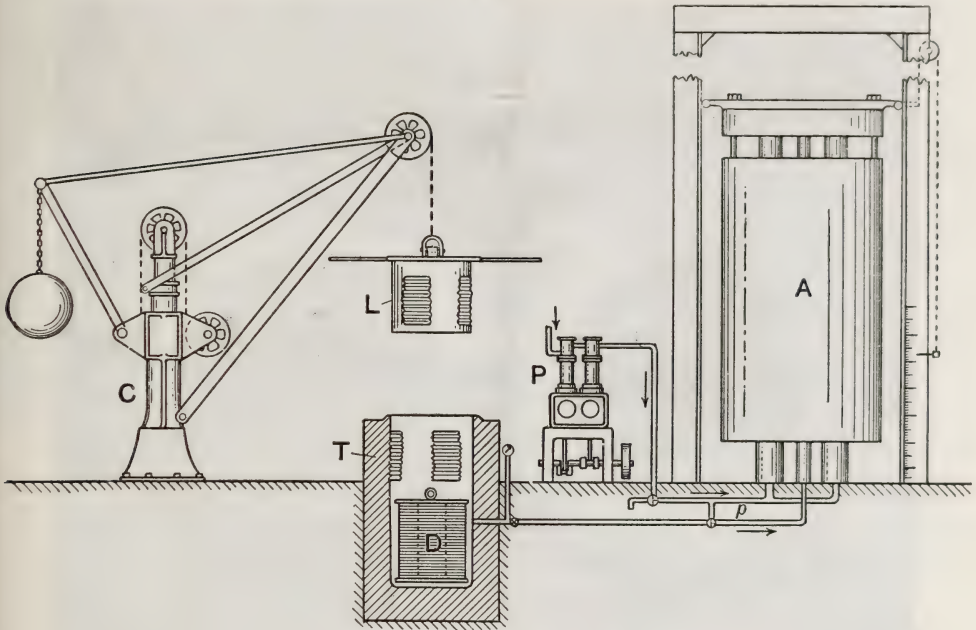
² I hear from Mr. Willoughby Smith that his Company also manufactured gutta percha-covered wire about that time for the same Government, and that the screw-press machine then used is still in their possession, but was too unwieldy to be sent to the *Society of Arts* for exhibition. The same press was subsequently used for covering submarine core.

at a pressure of 4 tons per square inch, and the upper part, weighing over 13 tons, was projected vertically through the roof to a height of about 25 feet, and, curiously enough, it fell down again into its old position. The thickness of wall of this cylinder was 7 inches; that of the new one was therefore increased to 12 inches, and this has hitherto withstood the pressure. We had the fractured tank photographed, with one of our men standing at its side to show the dimensions, and I will show you this photograph on the screen (Fig. 53).

amount of which has been used for submarine purposes.

Gutta percha-covered wires, which have to be laid in the sea, must be suitably protected against mechanical injury. For that purpose they are surrounded with a serving of hemp or other fibrous material, and then provided with a sheathing of iron or steel wires, or a metal ribbon; the whole is then termed a *submarine cable*. There are some interesting specimens of such cables on the table, exhibited by the Gutta Percha Company,¹ and

FIG. 52.



HYDRAULIC PRESSURE TANK.

In our last lecture I mentioned that I found gutta percha very permeable to the X-rays, and Mr. Alexander Siemens proposed to utilise this property to examine the gutta percha-covered wires with the *cryptoscope* for the detection of any defects in the copper conductor, particularly in "joints," or for finding air-bubbles. I will show you on the screen a set of gutta percha covered wires, mounted on a card, which was photographed in March last year by means of the X-rays (Fig. 54). I have also brought some joints and a coil of Atlantic core with me, which you can examine with the *cryptoscope* after the lecture.

I am able to give you some interesting figures as to the quantity of gutta percha hitherto used for electrical purposes, by far the largest

by Messrs. Siemens Bros. & Co. Amongst the latter you will see sets of the various types of the *Direct United States* and the *Commercial Cable Company's* Atlantic cables, of the Dover-Calais telephone cable, and others.

I have calculated the weight of gutta percha used for insulating the cores of all submarine cables manufactured and laid up to the end of 1896, from their length and type, and when these particulars were not available, I estimated them as nearly as possible. For the sake of convenience, I have divided the cables into four geographical groups as shown in Table XV.

¹ This company exhibited a kink cut out of the Dover-Ostend cable laid in 1863, specimens of their first cable, and of the 1865 Atlantic cable with a model grapnel.

TABLE XV.—SUBMARINE CABLES.

No. of Group.	Description of Cables.	Approximate length of Core.	Approximate weight of Gutta Percha.
		Nautical miles (Knots).	Tons.
I.	Trans-oceanic.....	42,000	6,000
II.	Round coasts of America	41,000	2,600
III.	Round east and west coasts of Africa.....	18,000	1,200
IV.	Round coasts of Europe, and Asia, and to Australia	83,000	6,200
	Total	184,000	16,000

total quantity of gutta percha used for electrical purposes. To the length given in Table XV. another 100,000 miles remain to be added, being the cables which have been laid by the various Governments and States for military defence,¹ so that a total estimate of 24,000 tons of gutta percha used for submarine cables alone is probably not too high.² To the latter figure a further allowance for underground cables, street wires, &c., would have to be made, which amounts probably to another 8,000 tons. As we shall presently

FIG. 53.



FRACTURED PRESSURE TANK.

I will now throw a map of the world¹ on the screen, which gives the various submarine cables at present in existence; but I must tell you that the total length of 184,000 knots given in the Table (which would be sufficient to pass more than $8\frac{1}{2}$ times round the Equator), includes the *cores* of all cables laid, whether they are still in existence or not;² my object being to ascertain the

see, the total consumption of cleaned gutta percha in the United Kingdom, from its beginning in 1845 till the end of 1896, amounts in round figures to 48,000 tons. I believe, therefore, that I am not very far wrong in saying that at least two-thirds, and probably more, of all the gutta percha used in this country has been employed for electrical purposes.³

¹ Not reproduced in the *Journal*.

² Table XVI. embodies the results of our analysis of the gutta percha employed for the manufacture of some of the early submarine cables and shows it to be of excellent quality. Specimens of these cores, which have been kept in air, sheltered from strong light, are still in perfect condition at the present moment. They have been manufactured by the Gutta Percha Company.

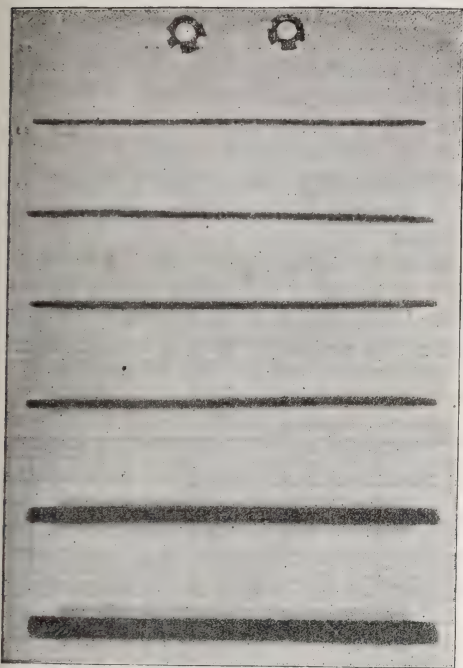
¹ *Journ. Soc. of Arts*, 1895, vol. 43, p. 744.*

² The writer in the *Journ. Soc. of Arts*, loc. cit., gives 23,000 tons for submarine cables alone, exclusive of the Government cables; but this is probably over-estimated.

³ This opinion is also shared by Mr. Willoughby Smith, who informs me that in the case of the Gutta Percha Company about 85 per cent. of the total output during the last 40 years has been for electrical purposes, but that taking the trade altogether the above estimate would probably be more correct.

With regard to the quantity of gutta percha used by the Postal Telegraph Department, I am able to give you some very interesting figures, kindly supplied to me by Mr. Hookey,

FIG. 54.



X-RAY PHOTOGRAPH OF CORES.

who informs me that the total length of gutta percha-covered wires in use by this Department up to 1896 was 30,000 statute miles. I calculate that about 660 tons of gutta percha have been

used for their manufacture. The total length of gutta percha-covered wires under the streets of London and its suburbs at the present moment is no less than 17,000 statute miles, corresponding to 375 tons of gutta percha. In 1875, Mr. Charles Fleetwood¹ stated before the Society of Telegraph Engineers that the total mileage of gutta percha-covered wire under the London streets was 3,500, the length is therefore now nearly five times what it was 21 years ago.

Before leaving this subject, I should just like to refer to an observation made by Dr. Werner von Siemens with the first underground wires, insulated with gutta percha, viz. that they became electro-statically charged like a Leyden jar² when one end of the conductor was brought into contact with one pole of a battery, whilst the other end was insulated, and the opposite pole of the battery connected to earth. To this property is due the fact that a momentary electric impulse, such as is used in signalling, imparted to the insulated wire, takes an appreciable time to arrive at the other end, if the wire is of considerable length. In this respect an underground line compares unfavourably with an overhead one of equal length, supported on porcelain insulators in the usual way. The extent of the retardation depends on the resistance of the conductor and on the inductive capacity of the insulator—i.e.,

¹ *Journ. Soc. Electr. Engin.*, 1875, vol. 4, p. 391.*

² *Poggendorff's Annal. d. Phys. u. Chem.* 1850, vol. 79, p. 481, also loc. cit. 1857, vol. 102, p. 66.* The electrostatic charge of an insulated wire, was also investigated by Faraday, Wheatstone, and Thompson, independently of Siemens.

TABLE XVI.—ANALYSIS OF GUTTA PERCHA ON THE CORES OF SOME EARLY SUBMARINE CABLES.

Year of manufacture.	Where laid.	When picked up.	When ana- lysed.	Percentage composition.				Ratio	Electrical properties 'per cube knot).		When Tested.
				Gutta	Resin	Dirt	Water		Insulation (Megohms.)	Inductive capacity (Micro- farads.)	
				G.	R.	D.	W.	$\frac{G.}{R.}$			
1850	England to France (Dover—Cape Grisnez).	1875	1888	85.0	9.1	2.7	3.2*	9.3	645	—	1875 (1)
1853	Scotland to Ireland (Port Patrick—Donaghadee).	—	1888	75.8	17.0	2.5	4.7	4.5	—	—	— (2)
1857	Ireland to Newfoundland (Valentia—Trinity Bay).	—	1897	76.1	20.3	3.0	0.6†	3.7	—	—	— (2)
1858	England to Holland (Orfordness— Haarlem).	1897	1897	80.2	12.8	2.9	4.1	6.3	589	.0785	1897 (3)
1863†	Persian Gulf (Kurrachee— Bushire).	—	1888	75.7	17.1	2.7	4.5	4.4	1,002	.0661	1865 (4)
1869	Black Sea (Kertch—Suchum Kahle).	1882	1882	68.9	23.9	3.2‡	4.0	2.9	2,630	.0645	1882 (3)

* Another piece of this core contained 4.2 per cent. of water.

† Year of manufacture of core, according to Mr. Willoughby Smith, junr.

‡ This figure is possibly a little too high on account of the Chatterton's compound between the layers.

§ This figure is too low on account of long exposure to air. Another specimen contained 1.4 per cent. of water.

(1) Tested by Mr. Willoughby Smith, senr., *Journ. Soc. Tel. Eng.*, 1875, vol. 4, p. 343.

(2) No data available for these cables.

(3) Our own tests of short lengths of the core.

(4) Clark and Sabine's Tables, p. 252.

the gutta percha covering—per unit length, and I have a number of curves here which have been kindly sent me for exhibition by my colleague, Dr. Frölich, of Berlin, showing the results of experiments, on the propagation of electric impulses through a cable under varying conditions.

HOME CONSUMPTION OF GUTTA PERCHA.

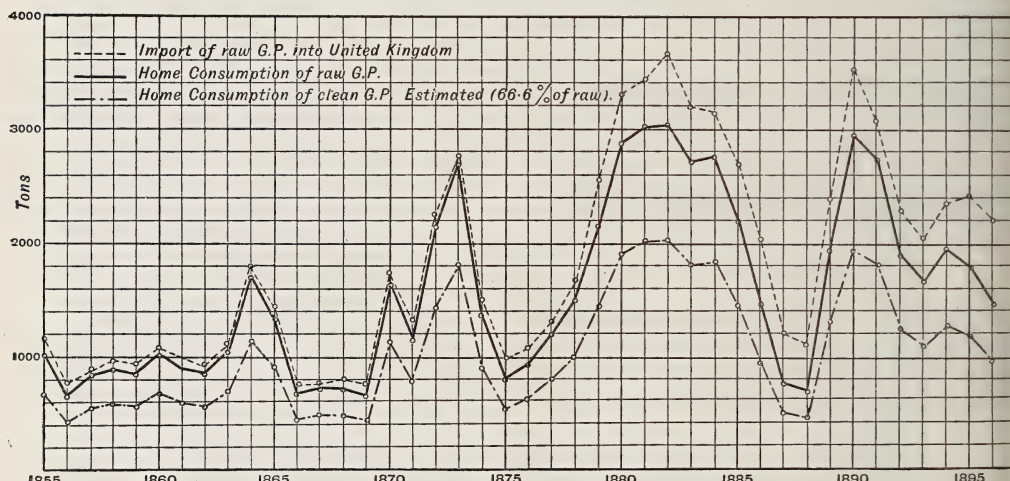
I should now like to call your attention for a moment to Diagram Fig. 55, which gives the *home consumption* of gutta percha for each year, from 1855¹ to 1896. The home consumption of the raw material is shown by a continuous line, and I have added the annual import of raw gutta percha into the United Kingdom during the same period, represented by a dotted line, for direct comparison; the latter curve is reproduced from Diagram Fig. 17 of the first

not strictly accurate, but sufficiently so for our purposes.

The total home consumption of *raw* gutta percha from 1855 to 1896 amounts to 65,467 tons. To this the total import¹ from 1844 to 1854, must be added, viz. 6,466 „ Giving a total home consumption of *raw* gutta percha from 1844 to 1896 of 71,933 „ or of *cleaned* gutta percha (allowing 33½ per cent. waste). 47,955 „ i.e. in round numbers 48,000 tons, as before stated.

In my first lecture (p. 133 *ante*), I stated that the total import of raw gutta percha into the United Kingdom from the beginning up to the end of 1896 was 82,716 tons, or in round figures

FIG. 55.



HOME CONSUMPTION OF GUTTA PERCHA FROM 1855 TO 1896.

lecture (*vide* p. 132 *ante*). Prior to 1878 the two curves are close to each other, but after this they diverge more and more, and this tendency, indicating an increasing export to other countries, is well sustained during the last five years.²

The third curve in Fig. 55, composed of dots and dashes, represents the annual consumption of *cleaned* gutta percha, and is deduced from that of the raw material on the assumption that the average loss on cleaning has been equal to the average obtained by us during the last 21 years, viz. 33½ per cent., which is, of course,

83,000 tons, and I may now add that I have since been informed that almost half that quantity was imported by the Gutta Percha Company. The re-export of raw gutta percha, during the entire period in round figures amounts to 11,000 tons or 13¼ per cent. of the total import.

USE OF HARDENED GUTTA PERCHA.

Gutta percha hardened by the extraction of its resin, either from the raw or cleaned material, is now chiefly used for the manufacture of golf balls, and although the estimate given in the prospectus of the Gutta Percha Corporation,

¹ No reliable statistical data of the re-export earlier than 1855 are available.

² A Table of figures will be given in the Appendix.

¹ During this early period the re-export from the United Kingdom was probably very small.

viz. that 500 tons of gutta percha, which would correspond to nearly 12,000,000 balls, are annually consumed in manufacturing them, is perhaps overstated, yet the quantity used for that purpose is certainly very large, and probably still increasing. The gutta percha used for golf balls has to fulfil certain conditions, and it may be useful to mention them here, viz. it should be tough, elastic, and not brittle at low temperatures; it should also be specifically lighter than water so that the balls do not sink if accidentally dropped into a ditch or pond.

In order to obtain all these good qualities it is requisite to start with the proper kind of raw material and to extract the resin as completely as possible. For testing the elasticity I devised an apparatus some years ago, somewhat resembling an Atwood's machine, and which I have already used to-night for the experiments on the stretching of gutta percha. Referring to this machine, which is illustrated in Fig. 47, p. 175, the tall stand, S, is provided with a scale, s, divided into feet and tenths, the entire distance between the clip, C, at the top (shown in plan), which carries the golf ball, and the stone plate, P, at the bottom, being exactly 10 feet, so that per cents. of the total height can be read off directly.

I will now show you some actual tests of golf balls with this apparatus, to which I have given the popular name of *bounceometer*. The first ball I am going to show you is a bad one, having had its resin only partially extracted, and still containing about 25 per cent. I place it in the clip and now let it drop on to the stone—you see it rebounds and reaches the point of the scale marked 30 per cent. The gutta percha from which the next ball is made has had the resin more completely removed, but not sufficiently, as it still retains 10 per cent. You see this ball rebounds to about 45 divisions of the scale. The third ball, which I shall test, is of excellent description, having only a very small percentage of resin; it rebounds to 60 divisions, the highest rebound hitherto observed by us. Here is a ball, made of balata, from which the resin has been completely removed, it bounces about 59 per cent.; and this other ball, made in August, 1896, from gutta percha extracted from leaves by my process, and not further treated with petroleum spirit like the previous materials, is quite equal, if not superior, to the latter.

In these days of Arctic exploration, I may perhaps be allowed to make a suggestion for the application of *hardened* gutta percha to another purpose, namely, to *ice-boats*.

A boat made of ordinary gutta percha was used as early as 1850, in Lady Franklin's Expedition of the *Prince Albert* in search of Sir John Franklin. It was put under the charge of Mr. Parker Snow, who reported very favourably on its behaviour¹, and gave a short account of his experience with it in the *Illustrated London News* of February 22nd, 1851, accompanied by a sketch showing the boat amongst the ice-floes. The diagram on the wall is a copy of this drawing². The boat was left in a cairn and was again used in the second expedition in 1852 by Captain Kennedy; but it had to be abandoned on account of the heavy pack-ice³. Gutta percha boats do not appear to have been used for subsequent Arctic expeditions, at least, I have been unable to find any record of such having been the case⁴. The boat sent out with the *Prince Albert* expedition was constructed by Messrs. Searle and Co., of South Lambeth, and covered with gutta percha at Wharf Road by the Gutta Percha Company. Its weight was only 18 lbs. A gutta percha boat built to carry two persons, but weighing 30 lbs., was exhibited by Charles Hubbard, of Dickleburgh, Norfolk, at the 1851 Exhibition (Class 8, No. 180).

I had an opportunity of analysing some gutta percha used for boat-building at the Royal Dockyards, Woolwich, more than 30 years ago, and found it to contain 40 per cent. of resin; but this would be too much for Arctic temperatures, as I shall presently prove to you. Besides the greater resistance to concussion which hardened gutta percha would offer at low temperatures, it would also have the further advantage that a thinner covering could be used, on account of its greater toughness, which would make the boat correspondingly lighter; its lower specific gravity also would tend in that direction.

I shall now show you by an experiment the superiority of *hardened* gutta percha over the natural material at low temperatures. On the table before me there is an Arctic Ocean *en miniature*, carrying three little boats made of

¹ *Voyage of the "Prince Albert" in search of Sir John Franklin*, by W. Parker Snow, London, 1851, pp. 76,* 82,* 218.*

² Not reproduced in the *Journal*.

³ *A short narrative of the second voyage of the "Prince Albert" in search of Sir John Franklin*, by Wm. Kennedy, London, 1853, p. 152.*

⁴ Dr. H. D. Traill, the well-known author of *The Life of Sir John Franklin*, R.N., published last year, whom I consulted in the matter was also unacquainted with other references to gutta percha boats in any of the subsequent search expeditions.

different kinds of gutta percha. The boats are distinguished by flags of different colours. The "red" flag marks the one made of best *Pahang*, the "black" that made of *common* gutta percha, and the "white" flag that made of the same material as the last, after extraction of the resin. I take one boat after the other out of the ice, and, laying it on an anvil, I give it a blow with a wooden mallet. First, the "red," which you observe withstands the blows without breaking; next, the "black," which is shattered into fragments, and would therefore not have withstood the action of the pack-ice; lastly, I take the boat with the "white" flag and give it a good blow; but strike it as hard as I will, it resists the blows of the mallet perfectly. The little boats have been in the tank, amongst the ice for several hours; but as they are only partially immersed in the water and the air is rather warm in this room, the conditions are naturally not quite so severe as they would be in the Arctic regions. I have therefore prepared another little experiment to show you what would happen there. This double-walled copper vessel contains a mixture of powdered ice and salt, having a temperature of about 10° or 15° C. below zero. In this mixture, strips of different kinds of gutta percha have been kept for a sufficiently long time to acquire that low temperature. I take one of these strips out quickly, and give it a blow with an iron hammer on a cold anvil. You observe it shows a crack—this is the *Pahang*. I take another strip and strike it in the same way—it actually breaks across; this is a material containing more resin than the former. I take a third strip—this withstands the blows perfectly; and from the mark on it I see it is the *hardened* gutta percha. This clearly shows you the superiority of that material over the others at exceptionally low temperatures.

In order to give you an idea how greatly the physical and mechanical properties of gutta percha are affected by the extraction of the resin, I have prepared Table XVII. which is so arranged, that it can be directly compared with Table XIV. (p. 179), giving similar particulars for different "brands" of gutta percha.

A large number of different raw materials of medium quality were cut up into small pieces, which were then intimately mixed and divided into two portions. One portion was then simply washed in the ordinary way with water, the tests of the cleaned material being shown at A; the other was treated with petroleum spirit until nearly all the resin had been ex-

TABLE XVII.—CHEMICAL COMPOSITION, PHYSICAL, MECHANICAL, AND ELECTRICAL PROPERTIES OF HARDENED GUTTA PERCHA.

Description of Material.	Percentage Composition.				Physical Properties.			Mechanical properties.		Electrical Properties (per cube knot).	
	Gutta		Water		Temperature when		Time of hardening. Minutes.	Tensile strength. lbs. per sq. in.	Elongation. Per cent.	Insulation. 75° F. 2nd min.	Inductive capacity. Microfarads.
	G.	R.	D.	W.	G. — R.	commencing to soften. o C.					
Reference mark.					becoming pliable. o C.						
Medium quality, cleaned in ordinary way.....	A	54.7	39.4	3.2	1.4	37.7	58.8	1.592	360	34,970	.0613
	B	93.0	2.8	1.7	33.2	57.2	91.1	5.662	285	27,410	.0575
Same material hardened by extracting the resin.....	C	97.3	1.2	0.3	78.5	58.3	94.4	6,757	380	6,640	.0471
	D	94.1	1.2	2.0	78.4	60.5	90.0	5,937	495	10,030	.0668
Various other materials hardened by extracting the resin.....	E	94.9	0.8	2.2	120.0	61.6	93.3	5,008	265	8,350	.0588

racted, and was then washed like the other; the results of the tests are shown at B. In a similar way, other mixed raw materials were treated with petroleum spirit and then cleaned in the ordinary way; the tests of these are shown at C, D, and E. The comparison between A and B is most interesting and instructive. Take, for instance, the softening temperature, which was 37.7° C before the treatment and 57.2° C after; or the time of hardening, which was reduced from 17 minutes to less than a minute. The breaking strength per square inch rose from 1,592 lbs. to 3,662 lbs., but the elongation diminished. The electrical properties, on the other hand, are but little affected, the insulation being practically the same as before, and the decrease of specific inductive capacity is probably due to the smaller percentage of water in the hardened material. The extraction of the resin in this case is far from complete as the results of the analyses show. The sample marked C is, in that respect, decidedly better, the raw material used in this case being of superior quality, and the results obtained with the hardened material correspondingly more favourable, particularly as regards the tensile strength, which is extremely high, viz. 5,757 lbs. per square inch. On comparison with Table XIV. it will be seen that the average figures there given in no case approach this high figure. The comparatively low insulation and exceptionally low specific induction of sample C are to be attributed to the particular description of the raw material and not to the extraction of the resin. The remaining two samples, D and E, were obtained from raw materials similar to B. The percentage of resin left in E is a remarkably low one, and the softening temperature of 61.6° C., is one of the highest hitherto observed in this class of material, and certainly higher than that of any natural kind of gutta percha.

ABSORPTION OF OXYGEN.

It has long been known that atmospheric oxygen in the presence of light, deteriorates gutta percha, and many experiments have been made in this direction but, I believe, none so comprehensive and exhaustive as those which I am now going to describe. The object of these experiments was to compare the avidity of the different "brands" of gutta percha in absorbing oxygen under otherwise similar conditions. For this purpose small spheres of cleaned gutta percha of 8 square centimetres superficial

area and 2 cubic centimetres contents were enclosed in glass tubes filled, with oxygen gas and inverted over mercury troughs, as shown in Fig. 56. Each trough was provided with six such tubes, and was so arranged that every tube could be brought over a kind of well and there filled with oxygen from one of the bottles of compressed gas, supplied by Brin's Oxygen Company. According to our tests this oxygen contained 7 per cent. of nitrogen, but was otherwise sufficiently pure for the purpose. Each tube had a capacity of about 30 ccm., and contained two spheres to accelerate the absorption. The tubes were refilled, when the composition of the residual gas approached that of the atmospheric air. The mercury troughs were placed outside a window on the south front of the laboratory, fully exposed to the sunshine, the latter being recorded by a Jordan's instrument. The experiment extended over 24 weeks, from the latter part of April to the beginning of October last, the total amount of sunshine during that period being about 680 hours, and the mean temperature during day-time 19.8° C. The results of the experiments are graphically represented in Fig. 57, the twelve materials being divided into four groups as before. I may add that the materials here employed were identically the same as those for which the specific gravity is given in Table X. and the absorption of water in Diagrams Figs. 44 and 45. The mutual relationship between the three members of each group (or class) is very apparent, and on comparing the various groups with each other, it is seen that the rate of absorption is by far the greatest in the case of *Soondie*, and the smallest in the *White* variety.

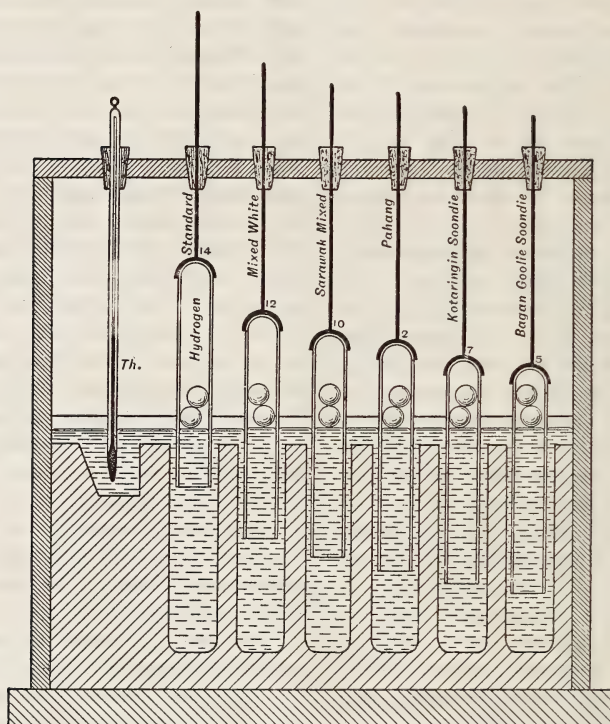
This is still more apparent in Fig. 58, which shows the smooth mean curves for the various groups (or classes), and in which the absorption of oxygen by *Balata* and gutta percha from *Leaves* is also added. The amounts of oxygen absorbed by the two last-named materials are, curiously enough, almost identical, both being higher than that of the *Soondie* during the first twenty weeks and smaller afterwards. As in the case of the absorption of water, the figures have been reduced to *pure gutta*, since here also the hydrocarbon is the active component. Thus reduced to standard conditions, the great avidity of the *Soondie* for oxygen is even more pronounced, whereas the *Genuine* is now practically reduced to the same level as the *White*. The gutta percha from leaves,

which, as we have seen, consists almost entirely of gutta, comes out much more favourably.

According to some experiments with spheres made from gutta percha obtained by Sérullas' and my own process respectively, there is practically no difference between the two as regards absorption of oxygen. A certain analogy between the curves representing the absorption of oxygen (Figs. 57 and 58) and those giving the absorption of water (Figs. 44, p. 172, and 45, p. 173) is unmistakable, although the order followed by the different materials is not exactly the same in each case.

strips has been subjected to a continuous stream of ozonised oxygen gas for three consecutive hours, and the places where the gas has played on the strips are marked by white lines; but, even if you examine them closely, you can only detect a slight shiny patch on some of them, for instance, on the strip made of Bagan goolie soondie and on that of balata and a little roughness on others, for instance, the three best kinds, Pahang, Banjer, and Bulongan. But even when in the form of thin tissue, gutta percha is hardly affected, as I will show you by an experiment. Through this Siemens' Ozoniser I shall pass a current

FIG. 56.



ABSORPTION OF OXYGEN BY GUTTA PERCHA.

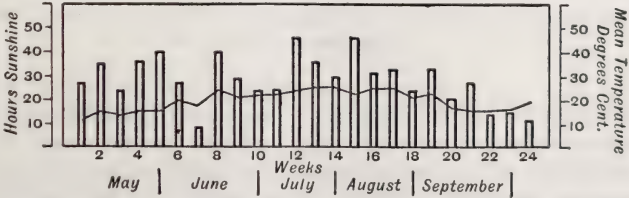
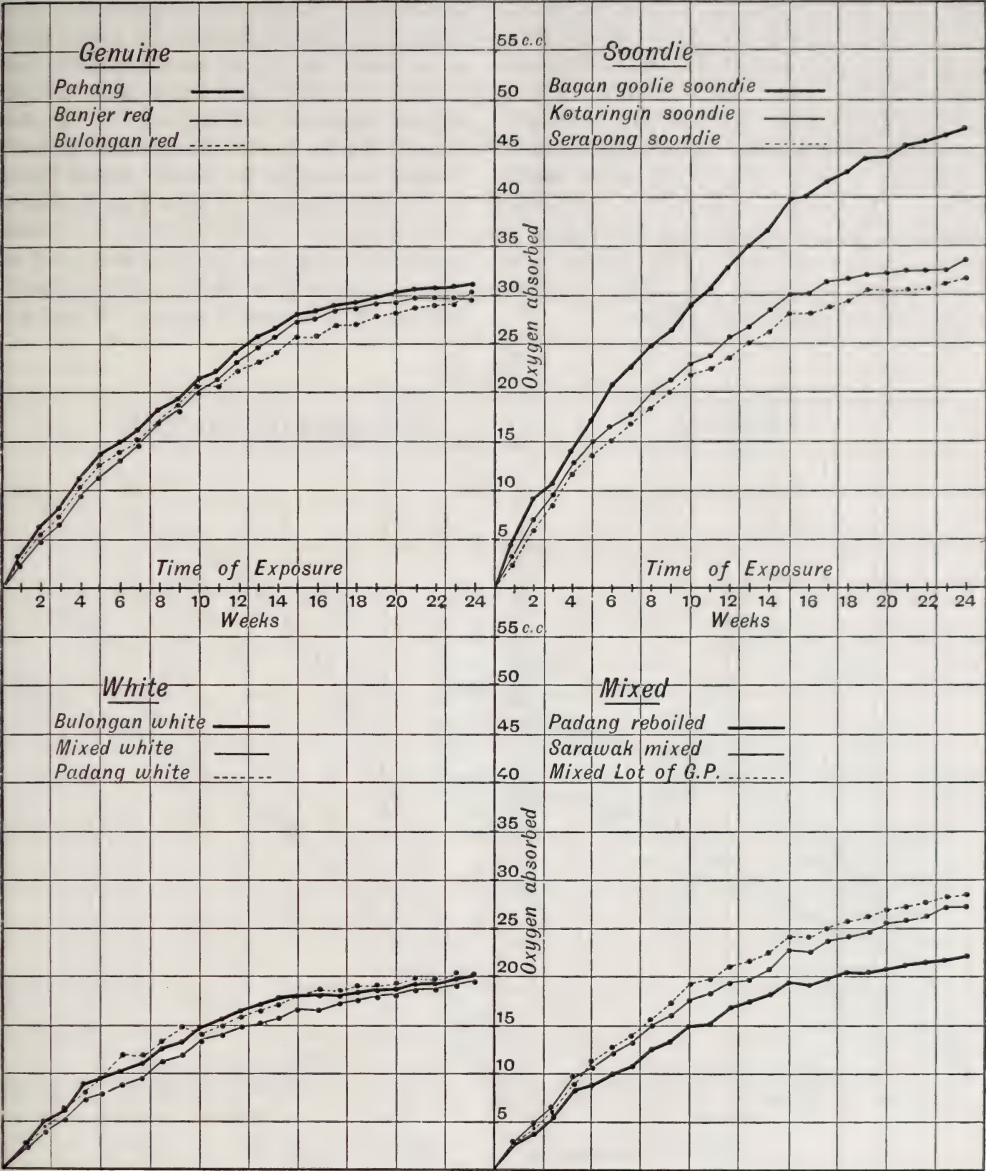
Exposed to daylight for 40 days during Spring of 1897. Total sunshine, 185 hours; mean temperature, 15° .

BEHAVIOUR TOWARDS OZONE.

The ready absorption of oxygen by gutta percha would lead one to expect that it would also be particularly susceptible to ozone, which as is well known, attacks caoutchouc very energetically. Contrary to what has repeatedly been asserted, such however is not the case. On this board are mounted a number of strips of gutta percha, representing the different brands of this material, and also strips of gutta percha from leaves and from balata. Each of these

of oxygen from this steel cylinder, and I will then start the induction coil. The oxygen issuing from the apparatus through this glass nozzle is strongly ozonised, as you will, I think, presently notice from the peculiar smell it imparts to the air. In this stream of ozonised gas I hold the thin tissue stretched over a frame, and although I expose it for over a minute, you cannot observe any action on it. I repeat the experiment with a membrane of pure Paracautchouc similarly stretched over a frame,

FIG. 57.



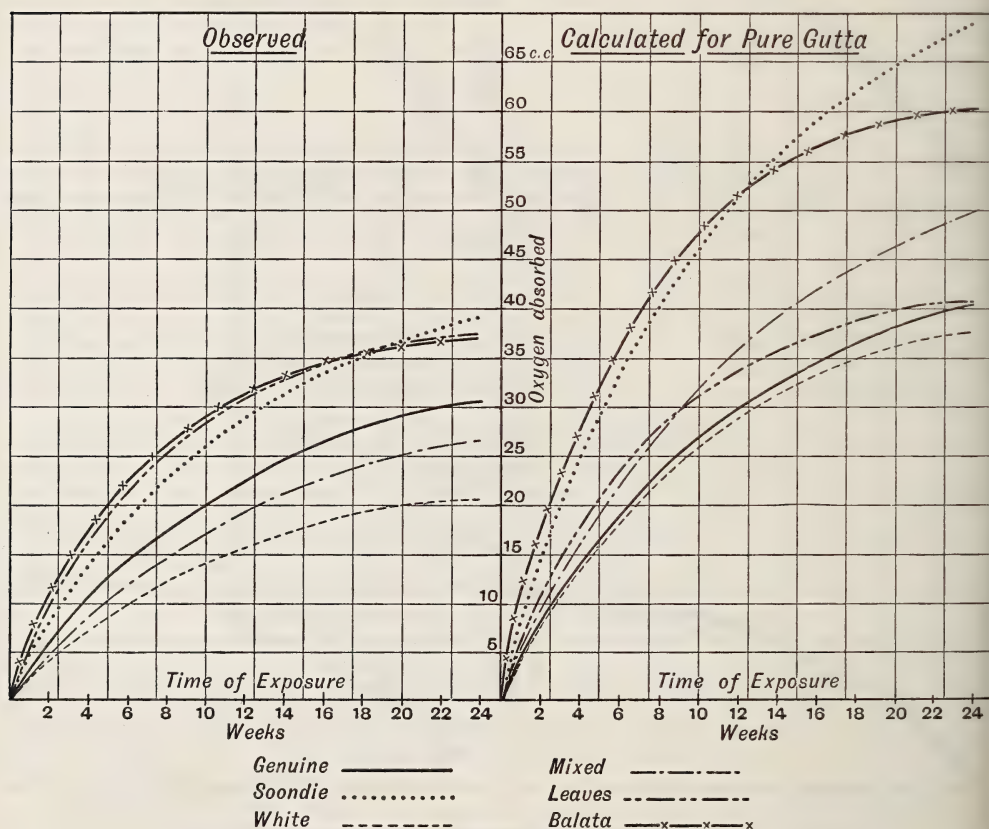
ABSORPTION OF OXYGEN BY DI FERENT BRANDS OF GUTTA PERCHA

Two Spheres each 16 m/m. dia.

and you observe that a few seconds suffice to pierce it, as if it were mechanically injured. But I can show you the marked difference in the behaviour of these two materials towards ozone in yet another way. Here is a glass tube, enclosing a piece of gutta percha tubing, and I pass ozonised air for a considerable time into the tube, but you observe no visible effect results. Another glass tube, containing a piece of grey vulcanised rubber tubing, will now be connected to the ozone apparatus, and a few minutes will suffice to produce numerous cracks on the surface, and when I take it out you will observe that the rubber has been very much affected.

as we have seen, but also by other causes, for instance, by any action tending to make the material porous, such as alternate wetness and dryness, the presence of substances which exercise a solvent action on gutta percha as a whole, or any of its components, &c. Certain alkaline substances and decaying organic matters also appear to act injuriously, but it is not infrequently quite impossible to assign a definite cause for the local decay observed. I have here a collection of short lengths of gutta percha-covered wires, which had been used for street work, and now show numerous places where the gutta percha covering has become defective. These wires

FIG. 58.



ABSORPTION OF OXYGEN BY DIFFERENT CLASSES OF GUTTA PERCHA.
Two spheres each 16 m/m. dia.

DETERIORATION AND PRESERVATION.

The principal cause of the destruction of gutta percha is the absorption of atmospheric oxygen, which alters the gutta and produces a brittle resin of quite a different nature to that originally present in the material. This destructive oxidation is greatly assisted by light,

have been kindly sent me by Mr. Preece, of the Postal Telegraph Department.

It is, however, not merely manufactured gutta percha which undergoes these destructive changes; for raw material of the very best kind succumbs in course of time to the combined action of air and light, as you will see from these pieces, which have been in our

show-room for a great number of years fully exposed to air and light, and are now completely resinified. They were originally of excellent quality, none of them containing more than 20 per cent. of natural resin.

The observation made during the experiments on the absorption of oxygen, viz., that the *Soondie* varieties of gutta percha, when exposed to light, are particularly prone to oxidation, is borne out by another experience. Here are some pieces of "Getah Sundek" from *Payena Leerii*, presented to Kew Gardens by Sir Hugh Low in 1883, and which were in perfect condition when I saw them in 1885. They are now quite resinified and yellow on the surface, owing to the exposure to diffused light in the Museum. I have here another piece of exactly the same material given to us by the Director of Kew Gardens in 1885, which I have since kept wrapped up in tinfoil, and you observe it has retained its original colour and freshness, showing no signs of oxidation.

Another and still better example for showing the beneficial effect of protection from light is Lobb's specimen of gutta percha, to which I referred in my first lecture. In spite of its great age (over 50 years) it is still in an excellent state of preservation, because it was sheltered from light in the cupboard of the Herbarium. Again, Oxley's "gutta percha cover," which I also showed you a fortnight ago, exhibits a well-preserved patch where it was formerly covered by a label.

Besides protecting gutta percha from light, it should, if possible, be also protected from air. This is the case when it is completely immersed in water, and in that respect submarine cores are more safely placed than subterranean wires.

Another way of excluding the air to some extent, is to varnish the gutta percha articles, and this method is resorted to by the War Office, for instance, in connection with the gun impressions, which have to be kept for reference.

For specimens of value, particularly those kept in museums, which may be required for analysis after a number of years, I venture to propose the use of a 4 per cent. solution of formaldehyde, which does not appear to affect the material, and is otherwise an excellent preservative; but my experience with that material is perhaps too limited to fully justify my doing so, and this must therefore be considered as a suggestion merely.

When gutta percha is oxidised, it becomes

porous and full of cracks. If it is used for insulating wires, the insulation fails at such places, since the moisture penetrates the pores and fissures and establishes an electric contact with the conducting wire.

A sound piece of core can be bent backwards and forwards at will without sustaining any injury; but if an oxidised piece, like this I have here, be taken it breaks immediately when bent. But I can show you a still more typical example of the decay of the material by oxidation. On this board there is an old gun impression, given to me at the Royal Arsenal. From a distance it looks the same as the others standing by its side; but when I give it a blow with my fist it is shattered to pieces like a sheet of glass. I could hit the sound impressions as hard as I liked without in the least injuring them.

ARTIFICIAL SUBSTITUTES.

In my last lecture I explained what I meant by *natural* substitutes, and I told you that I only knew of one material which deserved that name, viz. *balata*.

With *artificial* substitutes the case is different, at least if we are to include under that name all materials now used in place of gutta percha in any of its applications. Of such there is quite a number in existence under various names, e.g. celluloid, xylonite, ebonite, stabilit, ambroin, &c. &c., of which I cannot do more than mention the names to-night. I think, however, that a material which would really deserve the name of a substitute for gutta percha should be able to replace it to some extent in its principal application, i.e. the insulation of electrical conductors.

A material professing to fulfil this stipulation is the *Gutta Française* proposed by Mons. E. Mourlot,¹ of Paris, in 1878, and of which, at the time very favourable reports were given by the Press. It is prepared from the bark of the birch tree by distillation, and its price was given as 2.50 frcs. per kilogram. The material was said to improve gutta percha, when mixed with it, making it more durable in air and also securing it against the attacks of rats in underground conduits. In this connection, I may perhaps call your attention to an interesting object, which Mr. Hookey kindly lent me, viz. the skeleton of a rat, found entangled in some gutta percha-covered wires belonging to the Postal Telegraph Department.

¹ Ernest Mourlot, fils. French Patent Specification No. 133,310 of October 23rd, 1879; also his additional patent of September 3rd, 1880.

I have a large sample of *Gutta Française* here, and also some mixtures of this material with gutta percha; and, I will now show you that they, like gutta percha, become soft and plastic in hot water. Our experience with the French substitute has not been very favourable, as we have found that if any appreciable quantity of it is added to gutta percha it makes the latter coarse and brittle, and also unfavourably affects its electrical properties.

The latest substitute for gutta percha, of which samples, sent me only a day or two ago, are mounted on that board, is called *Velvriil*, a compound of collodion cotton and nitrated castor or linseed oil.¹ This material is said to be quite durable when exposed to the inclemencies of weather, and to be waterproof. In the process of manufacture, the velvriil paste is moulded like gutta percha, but it afterwards hardens and cannot then be softened by heat alone. Cord can be made by squirting the paste through a die, and it has been proposed to use this substance as an insulating covering for wires in place of gutta percha. Mr. Walter Reid has promised to send me a sample of insulated wire for testing, and it remains to be seen whether the results of the electrical tests are satisfactory.

Some *compounds* containing gutta percha are very useful for different purposes, and a specially useful one, consisting of a mixture of gutta percha, colophony, and Stockholm tar, is known under the name of *Chatterton's Compound*. It is largely used in connection with the manufacture of gutta percha-covered wires, as a binding material between the copper conductor and the gutta percha covering, or between the different layers of gutta percha on the core.

A compound consisting of equal parts of gutta percha, resin, and coal-tar, was proposed in 1847 by Surgeon Little to Dr. Oxley,² as a useful cement for various purposes.

CONCLUDING REMARKS.

I have now reached the end of my long programme, and must, I am afraid, plead guilty to having considerably exceeded the limits of the time allotted to these lectures; for this I now offer you my apologies. When it was first arranged that I should deliver this course of

lectures on gutta percha, and I was asked to decide about their number, I had some misgivings whether I should find sufficient material for three. Whilst preparing them, however, the subjects which appeared to merit attention multiplied to such an alarming extent that I had ultimately to contend with the reverse difficulty, viz. that of *l'embarras de richesse*. I have endeavoured as far as I could to do justice to other inventors and investigators, and any omissions in that respect I beg you not to attribute to want of appreciation, but solely to lack of time.

Some of the Tables, to which I have only briefly referred, will be given in an Appendix, and you can then refer to them at your leisure; but there will be a limit even in that respect, and I shall have to postpone any further remarks to a future occasion. I would have liked particularly to refer more fully to the various analyses and other researches,§ which were here described for the first time.

I have mentioned the various applications of gutta percha in the *Arts and Manufactures* in the course of this lecture, and I thought that a production demonstrating the suitability of this substance to works of *Art*, would form an appropriate conclusion to our subject.

I have here a *panel* made to my design by my old friend Mr. Theodore Scheerer, Chief of the Modelling Department at the Royal Iron Foundry at Wasseraffingen, in Wurtemberg. On the panel are the portraits¹ of Sir William Hooker and Dr. Werner von Siemens *en bas relief*, modelled in red-coloured gutta percha and enclosed in an appropriate frame. Gutta percha, made plastic by heat, was laid on zinc plates bit by bit and worked over with heated modelling tools. Of course my friend, who had never used this material before, had first to accustom himself to it, but the result shows how thoroughly he finally mastered all difficulties.²

On the top of the frame in the centre you observe a full-size representation of the flowering branch of the *Isonandra gutta*, described by Hooker in 1847, and in the corners are enlarged reproductions of the flower and fruit. At the side there are leaves of the *Isonandra* partially

§ In these I have been very ably assisted for many years by Messrs. W. Eichenauer and A. Smith, latterly also by Mr. F. Martin.

¹ Will be reproduced in the Appendix.

² The gutta percha is coloured with 5 per cent. of rouge. From different samples of gutta percha sent to my friend, he selected one having about 40 per cent. of resin, as the most suitable for the purpose.

¹ W. F. Reid and J. V. Earle's Patent, No. 21,995 of Nov. 19, 1895.

² *Journ. Ind. Archip.*, 1847, vol. 1, p. 22*.

verlapping each other, and there are other designs in leaves and flowers on the bottom part of the frame. All these are modelled from gutta percha of its natural brown colour. Between the two portraits is an actual piece of the first submarine core laid across the English Channel in 1850, and manufactured by the Gutta Percha Company. In the left-hand bottom corner there is a section of the first Atlantic cable, manufactured by Messrs. Glass, Elliott and Co. in 1857, and in the right-hand corner one of the last cables laid across the Atlantic Ocean, viz. the third one manufactured in 1894 for the Commercial Cable Co. by Messrs. Siemens Bros. and Co.

NOTE.—In conclusion, the lecturer expressed his indebtedness to Mr. Carl von Siemens, the chairman, and Mr. Alexander Siemens, the managing director of Messrs. Siemens, Bros. and Co. for kindly allowing him to bring the subject before the Society and enabling him to make the lectures attractive by numerous objects and specimens from their Works at Woolwich. Dr. Obach also expressed his sincere thanks to the following gentlemen and firms for their valuable assistance, the loan of interesting exhibits, &c., viz. :—The director of the Royal Gardens, Kew, Dr. W. T. Thiselton Dyer; the keeper and assistant-keeper of Museums at Kew, Messrs. J. R. Jackson and J. M. Hillier; the assistant-keeper of the Herbarium at Kew, Mr. W. B. Hemsley; the director and assistant-director of the Colonial Museum at Haarlem, Mr. F. W. van Eeden and Dr. M. Greshoff; the directors of the Botanical Gardens at Singapore and Buitenzorg, Mr. H. N. Ridley and Dr. M. Freub, and the director of the Pharmaceutical Institute at Berne, Prof. A. Tschirch; the curator of the Botanical Museum at Berlin, Prof. K. Schumann, and also Prof. E. Sérullas, of Paris; the director-general of Ordnance Factories and his first military assistant, Sir William Anderson and Com. B. H. Chevallier, R.N.; the engineer-in-chief of the Postal Telegraph Department and the assistant-engineer, Messrs. W. H. Preece and J. Hooke; the Council of the Institution of Electrical Engineers and the Secretary, Mr. F. H. Webb; the director of the Gutta Percha Company, Mr. Willoughby Smith; and Messrs. R. and J. Dick, of Glasgow, and H. Rost and Co., of Hamburg; Messrs. Behn, Meyer, and Co., of Singapore, particularly their Mr. H. Dittmar and Mr. L. Hüls, also Mr. C. P. Robertson of Glasgow, of Singapore; Mr. C. Sachs, of the British Museum; Messrs. G. P. Simpson, G. Hume, and A. R. Brooks, of London, and Mr. Th. Scheerer, of Vasserafinger; his colleagues, Messrs. W. Dieselhorst, P. Estler, and C. Hager; his assistants, Messrs. W. Eichenauer, A. Smith, and P. A. Bysi; C. F. Smith, K. Weathers, T. Crockford, and F. Martin.

Miscellaneous.

THE MINING INDUSTRY IN GALICIA.

From a very remote period the Iberian peninsula has been celebrated for its mineral wealth. The Phœnicians, and later on the Carthaginians, worked the gold and silver mines of Spain. Hannibal extracted daily, near Carthage, a quantity of those metals equivalent to 6,000 pesetas (£240). The most renowned ancient historians mention the riches of Iberia in precious metals, and relate that in the time of Justinian gold was found in the fields worked by the plough. Pliny the younger says that in his time 2,000 pounds of gold were extracted annually from Galicia, Asturias, and Portugal. The immense quantities of this metal drawn from Spain restored and replenished the public treasury of Rome. After the fall of the Roman Empire the mining industry received no great impulse from the Moors, and finally the discovery of the New World was the death-blow to the miners' industry in Spain. In fact, with the object of favouring in America an industry which was for them a source of great wealth the kings of Spain prohibited the working of mines in the peninsula. The United States Consul at Corunna says that owing to the persistent efforts of a few prospecting Englishmen, and to the progress made every year in processes for the extraction of refractory ores, it is probable that in a short time some of the old Roman mines will be worked on a large scale. The gold is found in the north-eastern part of Galicia, between the slate and granite formations. The ore is iron pyrites containing a little arsenic. The lodes run generally with the formation, north and south; they are well defined, and average about 14 ft. in thickness. Assays have given up to 4 ounces per ton and more, but the average is between 6 and 16 dwts. to the ton.

The following are the principal gold mines in Galicia. The Sagasta mines—In these mines some 2,000 metres of levels and cross-cuts have been driven to fully prove the lodes. Last year 1,600 tons of ore were extracted, equal—according to the assays—to 1,425 ounces of gold. The Fosas de Vila mines—These mines have been proved by sinking pits, and are being offered to the French market. The Josefina mines are of an arsenical iron pyrite. Assays made in Paris give over an ounce of gold and 2 to 30 grammes of silver to the ton. The Buena Esperanza—This mine is very much like the Josefina. It has a main lode over 2,000 metres long, about 4 ft. wide, and a depth of more than 100 metres. The ore assays give 9 to 10 dwts. to the ton, with less arsenic and more iron than the Josefina. The Virgen y S. Victor mines are on the same lode. The ore, although of a very complex nature, is very rich. There are many other concessions taken up, but for want of capital are not being developed. On the

banks of the River Sil there are remains of important "placer workings," probably Roman, and even to-day a considerable quantity of gold is washed from the deposits in the banks of this river by the peasant women, who stand in the shallow places and wash the stuff they have collected in "bateas" (wooden bowls), in the working of which they are adepts.

Tin is one of the ores which of late years has been much worked. There is a wide belt of tin-bearing formation which runs from Zamora through a corner of Portugal, through the province of Orense, and from there through Santiago up to the coast nearly 250 miles. The mines are worked under considerable difficulties, as they are situated for the most part in remote districts, and for want of means of communication the ore as a rule shipped to Havre has to be transported by mules to the nearest railway station. Since the fall in the price of tin the greater part of those workings have been closed. At Santa Cruz and in the Ferrol district several mines of very rich copper pyrites have been worked, but not systematically. The only mine at work now is near Monforte. The ore gives from 15 to 20 per cent. metallic copper. Formerly a good deal of antimony was mined, but since the fall in prices there has been little encouragement to work it. At Puebla de Brollon there is a well-defined lode in excellent condition for mining, and close to the railway; in fact, it was discovered during the construction of the line. From the concessions granted in the districts of Viobra and Quereno a large quantity of this ore could be extracted provided its price would show a small profit. Iron is one of the principal minerals, and so abundant that in any other country but Spain it would have received special attention from the Government; but, according to the American Consul, no practical interest appears to be taken in this most important source of wealth, and, unfortunately for the nation, nothing has been done, not even an attempt made to estimate the quantity. Broadly speaking, Galicia alone must hold considerably over 1,000,000,000 tons. The deposits are disseminated throughout the entire region, for the most part on or near the seashore, in positions which afford excellent means of shipping. The great drawback to the working of these mines is the per-centage of phosphorus. The La Torre mine is situated on the north side of Vigo Bay; its ore, by means of a short pier, can be tipped from the works into the holds of the ships alongside. The Incio zone contains one of the largest deposits, but very badly situated at about 100 miles from the coast. The Villaboa zone is also badly situated, yet much nearer the coast than Incio. The foregoing are representative deposits, and give a general idea of the industry. In the La Torre mine assays gave the following results: Iron, 48.25 per cent.; phosphorus, 1.61 per cent.; and sulphur, 0.02 per cent. In the Incio zone assays gave: Iron, 45.64, and phosphorus, 0.06 per cent., while in the Villaboa zone the assays were as follows: Iron, 46.2, and phosphorus, 0.225 per cent. The Consul says that the problem of working

these mines may be solved ere long, for there is continual coming and going of English, French, and German experts and chemists. Moreover the British Iron and Steel Institute held their annual meeting at Bilbao last year, and it was rumoured that they would also visit Galicia.

Another fact to be noted is that the supply of coal in Asturias is abundant. In 1894 the output was 1,000,000 tons, against 880,000 in 1893. The Ferrol district contains some fairly important deposits of plumbago, and the discovery of several mines of asbestos near Puente de Eume is quite recent. Very large slate quarries run nearly due north from Lugo up to the coast. In conclusion it may be stated that the mining laws of Spain are the best in the world for the protection of the miners' interests, and all possible facilities are granted by the Government. The concessions or grants are given in perpetuity, and can only be cancelled through non-payment of taxes which amount to about £1 10s. 10d. per acre, plus a royalty of 3 per cent. on the value of bullion, metal, or ore extracted.

Obituary.

ERNEST HART.—Mr. Ernest Hart, editor of the *British Medical Journal*, who died on Friday, 7th inst., at Brighton, after a long illness, had been a member of the Society of Arts since 1877. The first paper read by him to the Society was on November 26, 1884, and the subject was "The International Health Exhibition." Two years later, in May, 1886, he delivered his course of lectures on "Japanese Art Work." On February 24th, 1892, he read a paper on "Ancient and Modern Art Pottery and Porcelain of Japan," and in May, 1895, he gave two Cantor Lectures on "Japanese Art Industries." Mr. Hart was born in London in 1836, and received his early education at the City of London School, having obtained there the Lambert Jones Scholarship. He became a member of the Royal College of Surgeons of England in 1856, and in 1864 was appointed Ophthalmic Surgeon at St. Mary's Hospital. In 1858 he became a member of the staff of the *Lancet*, and in 1866 was appointed by the council of the British Medical Association to the editorship of the *British Medical Journal*, a weekly which he raised to its present important position. Until recently he was Chairman of the Parliamentary Bills Committee of the Association, and he was also for many years Chairman of the National Health Society. In 1894 he visited India, and at the Sanitary Congress held in Calcutta he expressed strong opinions on the actions of the Indian Government in respect to sanitary matters particularly, in regard to the prevention of cholera. He was a voluminous writer, and published papers in the Transactions of the Royal

Medical and Chirurgical Societies and in the Moorfields Ophthalmic Hospital Report, and, besides his editorial articles in the *British Medical Journal*, he contributed to the *Nineteenth Century*, the *Century*, the *Forum*, and other periodicals. He wrote the articles on Cholera and Vaccination in Dr. Clifford Allbutt's "System of Medicine," and the chapter on Water-borne Diseases in the "Twentieth Century Practice of Medicine."

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock :—

JANUARY 19.—"The Projection of Luminous Objects in Space." By ERIC STUART BRUCE, M.A.

JANUARY 26.—"Fireproof Construction of Domestic Buildings." By THOMAS POTTER.

FEBRUARY 2.—"The Cinematograph." By JULES FUERST. CAPTAIN W. DE W. ABNEY, C.B., F.R.S., will preside.

FEBRUARY 9.—"Compensation to Workmen." By A. D. PROVAND, M.P.

FEBRUARY 16.—"The Protection of Industrial Property." By J. F. ISELIN, M.A., LL.M.

FEBRUARY 23.—"Children's Sight." By R. BRUDENELL CARTER, F.R.C.S.

Dates to be hereafter announced :—

"Kites : their Theory and Practice." By Captain B. F. S. BADEN-POWELL.

"Stage Mechanism." By EDWIN O. SACHS.

"The Recent History of Papermaking." By CLAYTON BEADLE.

"The Preparation of Meat Extracts." By C. R. VALENTINE.

"The Production of Low Temperatures." By Professor J. A. EWING, F.R.S.

"Aerial Telegraphy." By Professor SILVANUS P. THOMPSON, F.R.S.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock :—

JANUARY 20.—"Recreations of an Indian Official." By the Right Hon. Sir MOUNTSTUART ELPHINSTONE GRANT DUFF, G.C.S.I., C.I.E., F.R.S. The Right Hon. LORD GEORGE HAMILTON, M.P., will preside.

FEBRUARY 17.—"The Plague in Bombay." By HERBERT MILLS BIRDWOOD, C.S.I., M.A., LL.D. (late Governor's Council, Bombay). The Right Hon. EARL SPENCER, K.G., will preside.

MARCH 10.—"India and Sir Henry Maine." By CHARLES LEWIS TUPPER, C.S.I. The Right Hon. Sir MOUNTSTUART ELPHINSTONE GRANT DUFF will preside.

MARCH 31.—"The Earthquake in Assam." By HENRY LUTTMAN-JOHNSON, I.C.S.

APRIL 21.—"The Rise, Progress, and Present

Position of the Native Press of Western India." By R. P. KARKARIA (of Bombay).

APRIL 28.—"India and Currency." By Sir EDWARD SASSOON, Bart.

MAY 19.—Paper by Sir ALFRED COMYNS LYALL, G.C.I.E., K.C.B., D.C.L. (Member of the Council of India). (Title to be announced.)

The meetings of January 20, February 17, and March 31, will be held at the Imperial Institute ; those of March 10, April 21, April 28, and May 19 at the Society of Arts.

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesday afternoons at 4.30 o'clock :—

JANUARY 18.—"My Recent Journey from the Nile to Souakim." By FREDERIC VILLIERS. Major-General Sir OWEN TUDOR BURNE, G.C.I.E., K.C.S.I., will preside.

FEBRUARY 15.—"The Goldfields of Klondyke and British Columbia." By W. HAMILTON MERRITT. Sir CHARLES MALCOLM KENNEDY, K.C.M.G., C.B., will preside.

MARCH 15.—"The African : what he is, and what he is capable of becoming." By the Rev. GODFREY DALE (Universities Mission to Central Africa).

APRIL 5.—"The Sugar Industry in the West Indies." By T. R. TUFNELL.

APPLIED ART SECTION.

The meetings of this Section will take place on the following Tuesday evenings, at 8 o'clock :—

JANUARY 25.—"Renaissance Woodwork in England." By J. HUNGERFORD POLLEN. WILLIAM LUSON THOMAS, R.I., will preside.

FEBRUARY 22.—"The Regalia of England." By CYRIL DAVENPORT. Sir GEORGE BIRDWOOD, K.C.I.E., C.S.I., will preside.

MARCH 8.—"The Making of a Stained Glass Window." By LEWIS FOREMAN DAY.

MARCH 29.—"English Art in Illuminated MSS." By Sir EDWARD MAUNDE THOMPSON, K.C.B.

APRIL 26.—"The Importance of Craftmanship." By Sir WILLIAM BLAKE RICHMOND, R.A., K.C.B.

MAY 17.—"Practical Points in Italian Majolica Painting." By WILLIAM BURTON, F.C.S.

CANTOR LECTURES.

The following courses of Cantor lectures will be delivered on Monday evenings, at Eight o'clock :—

CYRIL DAVENPORT, "Decorative Book binding." Three Lectures.

LECTURE I.—JANUARY 24.—The beginnings of bookbinding—Assyrian clay tablets in their cases—

Egyptian papyrus rolls — Vellum rolls — Roman diptychs—Medieval bindings in carved ivory, and metal covers with gems and enamels—Decorative bindings in Europe and the East up to and including the 15th century.

LECTURE II.—JANUARY 31.—Decorative book-binding in Continental Europe, chiefly Italy, France, and Germany, from the 16th to the 18th centuries inclusive, with some notice of Oriental bindings.

LECTURE III.—FEBRUARY 7.—Decorative book-binding in England from the 16th to the 18th century—Gold and enamelled bindings made for Henry VIII. and Queen Elizabeth—Bindings embroidered on velvet of the Tudor period, and on satin during the 17th century—Gold tooled work by Thomas Berthelet in the 16th century, by Samuel Mearne in the 17th century, and by Roger Payne in the 18th century, and the influence of these great binders upon the art.

HUGH STANNUS, "The Principles of Design in Form." Four Lectures.

February 14, 21, 28, March 7.

PROF. W. NOEL HARTLEY, F.R.S., "The Thermo-Chemistry of the Bessemer Process." Three Lectures.

March 14, 21, 28.

DR. D. MORRIS, C.M.G., "India Rubber." Two Lectures.

April 18, 25.

PROF. CARUS WILSON, "Electric Traction." Four Lectures.

May 2, 9, 16, 23.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JAN. 17.—Imperial Inst., South Kensington, 8½ p.m. Mr. H. A. Bryden, "South Africa, from the Cape to Ngamiland."

Geographical, University of London, Burlington-gardens, W., 8½ p.m.

Victoria Institute, 8, Adelphi-terrace, W.C., 4½ p.m. Prof. Hull, "The Glacial Epoch."

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. W. B. Bottomley, "Microbes: friendly or otherwise."

TUESDAY, JAN. 18... SOCIETY OF ARTS, John-street, Adelphi, W.C., 4½ p.m. (Foreign and Colonial Section.) Mr. F. Villiers, "My Recent Journey from the Nile to Suakin."

Royal Institution, Albemarle-street, W., 3 p.m. Professor E. Ray Lankester, "The Simplest Living Things." (Lecture I.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m.

Statistical (in the Theatre of the United Service Institution), Whitehall, S.W., 5 p.m. Mr. J. A. Baines, "The Recent Course of Trade within the British Empire."

Pathological, 20, Hanover-square, W., 8½ p.m.

Photographic, 12, Hanover-square, W., 8 p.m. Photo-Mechanical Meeting.

Zoological, 3, Hanover-square, W., 8½ p.m. 1. Dr. N. H. Alcock, "The Vascular System of the Chiroptera." 2. Mr. L. W. Byrne, "The General Anatomy of the *Holocephali*." 3. Dr. W. G.

Ridewood, "The Development of the Hyobranchial Skeleton of the Midwife-Toad (*Alytes obstetricans*)."

WEDNESDAY, JAN. 19... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. E. S. Bruce, "The Projection of Luminous Objects in Space."

Meteorological, 25, Great George-street, S.W. 7½ p.m. Annual General Meeting. Address by the President, Mr. E. Mawley, "Weather Influences on Farm and Garden Crops."

Microscopical, 20, Hanover-square, W., 8 p.m. Annual Address by the President.

Entomological, 11, Chandos-street, W., 8 p.m. Annual Meeting.

Archæological Association, 32, Sackville-street, W., 8 p.m.

Mining and Metallurgy, Geological Museum, Jermyn-street, S.W., 8 p.m. 1. Mr. James Park, "Notes on the Action of Cyanogen on Gold." 2. Mr. S. B. Newall, "Mexican Methods of Mining." 3. Mr. F. Cardell Pengilly, "The Successful Treatment of Tailings by the Direct Filling Process on the Witwatersrand."

THURSDAY, JAN. 20... SOCIETY OF ARTS (East Conference-hall, Imperial Institute, South Kensington, S.W.), 4½ p.m. (Indian Section.) Right Hon. Sir Mountstuart E. Grant-Duff, "Recreations of an Indian Official."

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Dr. W. G. Ridewood, "The Larval Hyobranchial Skeleton of the Anurous Batrachians, with special reference to the Axial Parts." 2. Mr. R. H. Burne, "The Abdominal Pore in the Myainidae."

Chemical, Burlington-house, W., 8 p.m. 1. Dr. Julius B. Cohen and Mr. Edward Brittain, "The Action of Caustic Alkalies on Amides." 2. Dr. Julius B. Cohen and Mr. H. T. Calvert, (i), "The Formation of Monomethylaniline from Dimethylaniline;" (ii), "Note on the Aluminium-Mercury Couple." 4. Mr. J. Elliott, "Action of Chloroform and Alkaline Hydroxides on the Nitro-benzoic Acids." 5. Messrs. J. Addyman Gardner and G. B. Cockburn, (i) "Researches on the Terpenes;" (ii) "The Oxidation of Fenchene." 6. Messrs. Bevan Lean and W. H. Whatmough, "The Preparation of Pure Iodine."

London Institution, Finsbury-circus, E.C., 6 p.m. Mr. Arnold Dolmetsch, "Musical Ornamentation in the 16th, 17th, and 18th Centuries."

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Dewar, "The Halogen Group of Elements." (Lecture I.)

Historical, 28, Jermyn-street, S.W., 8½ p.m.

Numismatic, 22, Albemarle-street, W., 7 p.m.

FRIDAY, JAN. 21... Royal Institution, Albemarle-street, 8 p.m. Weekly Meeting. 9 p.m. Sir John Lubbock, "Buds and Stipules."

Junior Engineering, Westminster Palace Hotel, S.W., 8 p.m. Prof. A. C. Elliott, "Laboratory-Testing Machines, and the Latest Example."

Philological, University College, W.C., 8 p.m.

Quekett Microscopical Club, 20, Hanover-square, W.C., 8 p.m.

Physical, Chemical Society's Rooms, Burlington-house, W., 5 p.m. 1. Prof. O. Lodge, "Electrical Signalling without Conducting Wires." 2. A Tesla Oscillator will be exhibited by Prof. S. P. Thompson.

SATURDAY, JAN. 22... Botanic, Inner Circle, Regent's-park, N.W., 3½ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Patrick Geddes, "Cyprus." (Lecture I.)

Journal of the Society of Arts.

No. 2,357. VOL. XLVI.

FRIDAY, JANUARY 21, 1898.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****EXHIBITION OF BOOKBINDINGS.**

In connection with Mr. Cyril Davenport's Cantor lectures on "Decorative Bookbinding," an Exhibition of specimens of Foreign and English Ornamental Bindings to the end of the eighteenth century will be held in the Reading Room of the Society. The Exhibition will be open daily from Monday, 24th inst. to Monday, February 7th. Hours: 10 to 5 p.m., and on the evenings of Mondays and Wednesdays from 6 to 9.

Members can admit their friends by the use of the usual meeting tickets supplied to members. There will be no restriction as to the number of tickets issued.

Non-members of the Society can obtain cards of admission on application to the Secretary, Society of Arts, John St., Adelphi, W.C.

COVERS FOR JOURNAL.

For the convenience of Members wishing to bind their volumes of the *Journal*, cloth covers will be supplied post free for 1s. 6d. each, on application to the Secretary.

Proceedings of the Society.**SIXTH ORDINARY MEETING.**

Wednesday, January 19, 1898; MICHAEL CARTEIGHE, F.C.S., Member of Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Bosley, Walter Joseph, Sewerage Outfall Works, Guildford.

Boyd, Captain Mossom Archibald, R.E., Holt-cottage, Burton-lane, York.

Braham, A. C., 9, Broughton-road, Ealing, W.

Clarke, Stephenson Robert, Borde-hill, Cuckfield, Sussex.

Cunnington, Thomas C., 23, Queen-Anne's gate, S.W.

Doulton, H. Lewis, Lambeth Pottery, S.E.

Elmer, J. J., Ethelmar-house, Waverley-road, Crouch-end, N.

Forrester, William, Powell-house, Staplehurst, Kent.

Griffith, William R., Rydal Mount, Upper Bangor, North Wales.

Hoskins, Nandy W., Invicta-house, Plumstead-common-road, S.E.

Lawson, Allan John, 25, Canning-road, Croydon, Surrey.

Liversedge, Alfred J., 32, Victoria-street, Westminster, S.W.

Macadam, H. E., Ensleigh, High-street, Wanstead, Essex.

Martin, David, 2, Provan-place, North Montrose-street, Glasgow.

Mitchell, Charles Frederick, Seeburg, Pennard-road, Shepherd's-bush, W.

Ransome, John Wilmer, 62, Finsbury-pavement, E.C. Rathbone, Richard Reynolds, J.P., D.L., Glan-y-Menai, Menai-bridge, Anglesey.

Small, William, 294, Camden-road, N.W.

Speak, John, Kirton-grange, Kirton, near Boston.

Thudichum, George Dupré, 2, Edinburgh-mansions, Howick-place, S.W.

Turnbull, R.A., Langham-hotel, W.

Wheatley, Richard, junr., 42, Brougham-street, Birmingham.

The following candidates were balloted for and duly elected Members of the Society:—

Hilditch, James Bracebridge, Asgill-house, Richmond, Surrey.

Wattenbach, Oscar, 15, Long-lane, E.C.

Welton, William Shakspeare, 46, Canfield-gardens, N.W.

The paper read was—

THE PROJECTION OF LUMINOUS OBJECTS IN SPACE.

By ERIC STUART BRUCE, M.A., OXON.

It is a well-known fact of optics that the retina of the human eye retains the impression of an object for a short time after the object itself has been withdrawn. This phenomenon is called "persistence of vision," and the images which thus remain on the retina after the exciting cause is withdrawn are called sometimes "positive accidental images," sometimes "incidental images," and sometimes "consecutive images." We can recognise

persistence of vision without the aid of any instrument. Were it not for persistence of vision the rain-shower would be falling drops, not lines, of water; the meteor in the skies would be bereft of its glories, being merely a fiery ball, leaving no glittering path behind it, and in man's imitation of a meteoric shower—a display of fireworks—the most elaborate Catherine wheel ever designed would resolve itself into a few points of fire.

But from time to time various optical instruments have been devised to specially illustrate persistence of vision. Foremost amongst the older instruments was the zoetrope, in which successive positions of the bodies of human beings and animals in motion were in turn so rapidly brought before the retina that the synthesis of the various impressions gave a fairly lifelike representation of the actions of the subjects. But now the zoetrope has been improved into the cinematograph, in which instantaneous photography supplies faithful representations of the different positions of objects in motion, and in place of the puppet-like performance of the zoetrope we have photographs which come to life, and any past scene, whether it is the bustle of a railway station, the execution of a ballet on the stage, the breaking of a tempestuous sea on the shore, or the splendours of a Jubilee procession, can be preserved and re-acted for the delectation of posterity. In the face of such an excellent contrivance for illustrating persistence of vision, it may seem unnecessary to introduce any new instrument. I have, however, five claims for bringing the instrument I have invented and called the "aerial graphoscope" before the notice of this Society. I may also add that the invention of the aerial graphoscope is of prior date to the evolution of the cinematograph.

1. It shows the general effects of persistence of vision in a striking manner, so that a whole audience can see them without strain or fatigue to the eyes, as there is no interruption to the image by intervening shutters or segments.

2. Besides showing the general effect of persistence of vision, it carries its penetrative qualities of instruction further than the older instruments designed to illustrate the phenomenon: for instance, it appears to be the only instrument which shows the difference in intensity between the real and incidental image, and the gradual fading from the retina of incidental images.

3. It forms a most delicate test of the exact duration of persistence of vision on the individual retina.

4. The apparatus is a valuable adjunct to the resources of the optical lantern, as, by its means, a lantern picture can be projected in space and bold relief without the usual, and as was once thought necessary, white sheet or screen.

5. Because the aerial and transparent images produced can be made so eminently spectral and ghostlike, the apparatus supplies a new and artistic method of depicting the supernatural in stage effect.

Before treating of the more strictly scientific uses of the aerial graphoscope I will explain the action of the instrument. Its vital principle is this narrow lath of wood, painted white in front, with a grey centre gradually diminishing in shade to white. This lath can be rapidly revolved at its centre by means of a multiplying wheel, or, if it is preferred, by an electric motor. On the lath, which is now at rest, I throw a small portion of a magic-lantern picture representing a statue. When the lath is revolved rapidly you see the whole picture before you, apparently in space (experiment shown), the explanation being that as the lath revolves it receives the different portions of the picture in turn. Owing to the fact that the retina of the eye retains for a short time any impression presented to it, the various portions have not time to fade before the whole picture has been successively projected on to the lath. The picture, therefore, does not really exist as a whole in the place where it appears. As a whole it emanates from each one's retinal organ, and is developed by each one's individual powers. It may, therefore, be correctly described as an image in space, and its ghostly character is made apparent when I place this vase of flowers and other objects behind the revolving lath, the real objects being seen through the vision. (Experiments shown.)

When a lath of 76 centimetres long and 5 centimetres broad was revolved by an electric motor placed 1 metre 14 centimetres from the nozzle of the lantern, the number of revolutions per half-minute required to produce a really steady image was 318. The lath used this evening is 5 centimetres wide, so as to obtain a very brilliant picture, but the persistent image is obtainable by using a surface of only 1 millimetre in width. On this lath I have gummed a sheet of thin white paper, leaving a surface of 1 millimetre projecting over the edge of the lath. On this surface I will project an infinitesimal portion of a lantern picture by means of a lantern from behind. When the

lath revolves you see a very faint image of the crescent moon in the lantern. The image is clear though necessarily very faint as the receiving surface has been then reduced. (Experiment shown.)

Thus the general effects of persistence of vision have been clearly demonstrated. I will now point out the educational value of the apparatus in showing the difference in intensity between the real and incidental image.

You will have noticed that the centre of the lath is tinted grey, gradually diminishing in shade to white from the centre towards the extremities. This has been done to preserve the artistic effect of any picture thrown upon it. It is in fact there to reduce to some extent the effect of the variance in intensity between the real and the incidental image: to give the centre of the picture as far as possible the same intensity of illumination as the outer portions. The centre of the lath in revolving is always before the eye. Here there is no incidental image. When there is no picture in the lantern and only the bright disc shown, though that centre is tinted grey there is a brilliant centre in the disc, white in comparison with the outer portions. Here you see the difference in intensity between the real and the incidental image. (Experiment shown.) Let me call your attention also to the diminishing intensity of the illumination of the disc from its centre towards the extremities as it becomes less and less reinforced. This shows the gradual fading from the return of incidental images. (Experiment shown.) I now fix a piece of white paper upon the central portion of the lath, and then throw a picture upon it as it revolves. The contrast between the central portion and the rest is still more strongly marked. (Experiment shown.)

When objects in rapid motion are projected on the revolving lath, very curious multiplication phenomena are observable. If I were to take this ball and drop it between the lantern and an ordinary white screen, its shadow would be a blur made up of a number of images of the falling ball. When, however, I substitute the revolving lath for the screen instead of the blur we get four distinct images of the falling ball. (Experiment shown.) Again, if I revolve this iron ring between the lantern and screen we see a number of distinct rings. (Experiment shown.) I vibrate this wire, and it is likewise multiplied. I twist about this chain and it resolves into fantastic shapes. (Ex-

periments shown.) The multiplication of the shadow of the ring and of the ball and other moving objects is obviously caused by the relative movements of the objects and revolving lath affording an interrupted view of the shadow of the ball in its descent and the ring in its revolutions. When I cause a number of electric sparks in rapid succession to pass between two terminals, and move the terminals backwards and forwards, we do not see a continuous line of light, the blurring of a number of electric sparks, but persistent images of electric sparks at intervals. (Experiment shown.) If the intermittent electric discharge was of sufficient intensity to illuminate objects, any objects in motion seen by its flashes would be multiplied like the ring and ball on the incidental disc. I have, however, another means of producing an intermittent beam of light by revolving this disc with two slits in it in front of this limelight lantern. When in the path of this intermittent beam I swing this ring backwards and forwards, you see the same effect as on the incidental disc. (Experiment shown.)

A most remarkable experiment, showing the multiplication phenomena, is one which I have called the "hieroglyphic effect." I take a slit, such as is used for spectrum work, and move it backwards and forwards in the lantern, when the image appears not only multiplied, but so distorted as to give the appearance of hieroglyphic writing. The multiplication and distortion depend upon the relative movements of the lath and the slit in the lantern, and also upon the centring or not of the image on the revolving lath. The bend of the U and truncated stem of the W appear to be caused by the central and real portion of the disc. (Experiments shown.) You will notice that the multiplication phenomena are sometimes seen reversed. There is another striking experiment on the same principle. In the lantern is a colour disc of blue, red, and green sectors. When this is revolved in the lantern and its projection cast on any ordinary screen, white light is produced from the mixture of colours remaining on the retina. When, however, we cast the projection on the incidental disc we fail to obtain white light, except on the real portion of the disc. This experiment shows very clearly the boundary lines of the real image. (Experiment shown.)

The exact time that the persistent image remains on the retina varies with the intensity of the illumination with which objects are

perceived and with the sensitiveness of the individual retina. Probably, also, the perception of persistence varies with the sensitiveness of that complex mechanism which connects the rods and lines of the retina with the grey matter of the brain. It is conceivable, too, that the brain itself has a part in determining the time of persistence. It seems that a variety of other circumstances are also responsible for the duration. The same person often has a different capacity of persistence of vision when he is well from what he has when he is ill, and, as I have ascertained by actual tests, he can have a very different capacity at different times of the day according to the circumstances under which he is placed, for instance, within a few minutes his capacity of persistence of vision may widely differ if within those moments he has taken violent physical exercise. In many cases persistence of vision shows different durations for objects viewed under light of different colours. It also varies with the condition of the retina itself at the moment. Persons who have rested the retina by being in the dark show a different capacity from that shown when the retina is more fatigued. I have mentioned that the aerial graphoscope affords a most delicate test for ascertaining the time of persistence on the individual retina. In this respect the apparatus promises to be useful in the physiological laboratory. I have myself taken 67 tests with different persons under varying conditions, the results of which are tabulated on the diagrams before you. We have seen that to produce a good steady image on the incidental disc a speed of some 318 revolutions a half-minute is desirable. The persistent image is, however, visible, though not steady, at a much lower rate than that, the exact rate being a matter of individual capacity. If we ascertain the rate of revolutions at which each individual can just see persistence of vision, we can calculate his particular capacity of persistence.

The arrangement of apparatus I have employed for the purpose is as follows. A lath of 76 centimetres long and 5 centimetres broad was revolved by an electric motor, provided with means of counting its revolutions. The motor was worked by means of a 5 cell electric storage battery, through a resistance with sliding contact. The lath was placed 1 metre 14 centimetres from the nozzle of the lantern, in which there was an ordinary blow-through oxyhydrogen jet. In the lantern was placed a slide representing a statue.

TABLE I.—AERIAL GRAPHOSCOPE TESTS OF PERSISTENCE OF VISION.

Miscellaneous Group of 25 Persons.

	No. of revolutions per $\frac{1}{2}$ minute.	GIVES	{ Persistence of vision in seconds.
1 M.	27* (self)		2.2
2 M.	27* (optical assistant)		2.2
3 F.	27		2.2
4 F.	27		2.2
5 F.	27		2.2
6 F.	37		1.62
7 M. child..	37		1.62
8 F.	27		2.2
9 M.	75		.8
10 F.	27		2.2
11 M. child..	27		2.2
12 M. child..	27		2.2
13 F.	41 (shortsighted)		1.46
14 M.	27		2.2
15 F.	27		2.2
16 M.	27 (sportsman)		2.2
17 F.	27		2.2
18 M.	92 (engineering student)		.652
19 F.	34 (shortsighted)		1.76
20 F.	72 (sister of engineering student with high record above)		.83
21 F.	40		1.5
22 M.	50		1.2
23 M. youth..	27		2.2
24 M. child..	34		1.76
25 M. child..	36		1.6

* Mean of four readings. Average 1.36. Mean 1.19.

Table I. shows a group of 25 tests I took in 1895. The low rate of 27 revolutions per half-minute, at which the persistent image was just visible to myself and assistant, both accustomed to observe the incidental disc, was taken as the lowest limit for the test. This was the mean of 4 readings, the variations in the running of the motor being but slight. The persons taken for the test were of both sexes and of various ages and classes, and described themselves as of good sight, except two marked on the list. None wore glasses. In the Tables I. and IV. M stands for male, F for female. The apparatus used for these earlier tests was somewhat more rough and ready than that which I employed for the later groups, but I consider the results of the tests sufficiently

TABLE II.—AERIAL GRAPHOSCOPE TESTS OF PERSISTENCE OF VISION.

Group of 25 Boys before and after Running (First Readings).

	Before running.			After running.		
	No. of revolutions per $\frac{1}{2}$ minute. } GIVES	{	Persistence of vision in seconds.	No. of revolutions per $\frac{1}{2}$ minute. } GIVES	{	Persistence of vision in seconds.
1.....	52		1.15	38		1.58
2.....	66		.909	71		.845
3.....	44 (head boy of school)		1.363	53		1.13
4.....	73		.821	46		1.304
5.....	37 (third boy in 4th form)		1.62	32		1.87
6.....	65		.923	34		1.76
7.....	44 (top boy 4th form)		1.363	42		1.428
8.....	91		.659	98		.612
9.....	51 (middle boy in 5th form)		1.176	46		1.304
10.....	53 (5th Standard)		1.13	48		1.25
11.....	51 (nearly top of his class)		1.176	50		1.2
12.....	39 (top of Standard 5; very clever; best example I have had)		1.53	40		1.5
13.....	49 (fourth in 7th Standard)		1.22	42		1.428
14.....	54		1.1	56		1.07
15.....	74		.8108	53		1.13
16.....	57		1.05	57		1.05
17.....	50		1.2	47		1.27
18.....	82		.73	53		1.13
19.....	69		.87	73		.821
20.....	82		.73	42		1.428
21.....	58		1.03	63		.95
22.....	56		1.07	50		1.2
23.....	92		.65	67		.89
24.....	53		1.13	43		1.39
25.....	59		1.01	40		1.5
26.....	60		1	55		1.09

Average 1.05. Mean .98.

Average 1.23. Mean 1.07.
7 boys' persistence was lowered, 18 increased,
and 1 boy the same.

accurate to quote, as several of the tests were the mean of four readings, the variations in the running of the motor being but slight. I may also add that one person that I had tested with the rougher form of apparatus came out the same when tested again with the more improved arrangement. In this group you will notice that 14 of the 25 persons could see the persistent image at the low test rate selected, viz., 27 revolutions per half-minute. This gives a long persistence on the retina—as much as 2.2 seconds. In making these calculations it was necessary to remember that the lath being revolved at its centre, each part of the picture is reinforced

twice during each revolution. The shortest persistence on this list is .652. The reason for the high readings is doubtless the brilliant oxyhydrogen light employed in the lantern, and placed at such a short distance from the revolving lath. They show that one of the most determining factors in the duration of persistence of vision is the intensity of the illuminant under which objects are seen, and that the quotation of any average for persistence of vision such as $\frac{1}{30}$ or $\frac{1}{50}$ of a second without any reference to the nature of the illuminant is exceedingly vague.

The results of Table II. are of special interest as it tabulates tests of 26 subjects

before and after bodily exertion. The subjects were schoolboys selected from various schools; for instance the first seven were taken from one school. They all undertook to be tested, first, in their normal condition, and second, immediately after violent exercise in the form of running for several minutes. No one was tested the second time until he was panting for breath. In the results of these tests it will be noticed that the persistence of every subject was altered by running except one, who registered the same figure, viz., 1·05 in each case. The second of seven was lowered, but that of nineteen was heightened. From this result it would seem that bodily fatigue tends to prolong persistence of vision, which I believe is the tendency of illness. These tests have not been treated in any way from a medical point of view, but I may point out one case appearing in Table II. of a person enjoying perfect health, who said she had never known the slightest indisposition in her life, she comes out at 1·39—a medium reading.

It would be interesting to hear the opinions of those conversant with the theories of vision, as to whether it is their opinion that the varying durations of persistence of vision in different individuals and under different circumstances does not tend to support the photographic theory of vision, which seems likely to have had considerable confirmation from certain experiments with X-rays on the retina—shadowgraphs having been observed on the retina, as if it was a sensitive plate. Since by this theory an actual photograph of everything we see is fixed on the retina by one chemical process and removed by another, may we not suppose that these chemical processes would not go on at the same rate in the retina of different persons, and that the rate of the removal of the visual photographic image corresponds to the rate of what we call the incidental image. Perhaps also it is reasonable to expect that, after the system has been weakened by bodily exertion, the speed of the removal of the photograph would be lowered.

Table III. shows tests made under different colours, compared with white light, the rays from the lantern passing through red, green, and violet glasses. These tests were made with five females. Those marked in the Table ** are the mean of three readings. The reason why I occasionally took the three readings was not that the subjects were undecided, but because I was anxious to be sure of the accuracy of the tests by obtaining several uniform runnings of the motor. It is

satisfactory to state that the motor gave very uniform readings, coming out time after time exactly the same figure. With regard to these

TABLE III.—AERIAL GRAPHOSCOPE TESTS OF PERSISTENCE OF VISION UNDER WHITE LIGHT AND COLOURS. (FIVE PERSONS FEMALE.)

White Light.

	No. of revolutions per $\frac{1}{2}$ minute. }	GIVES }	Persistence of vision in seconds.
1	63*		·95
2	70*		·857
3	36		1·6
4	51		1·176
5	36		1·6

Average 1·236. Mean 1·23.

* Mean of three readings.

Red Light.

1	63*		·95
2	60*		1
3	36		1·6
4	46		1·304
5	73		·821

Average 1·147. Mean 1·1.

* Mean of three readings.

Violet Light.

1	67*		·89
2	60*		1
3	28		2·14
4	60		1
5	60		1

Average 1·206. Mean 1·38.

* Mean of three readings.

Green Light.

1	61*		·98
2	53		1·13
3	37		1·62
4	72		·83
5	39		1·53

Average 1·21. Mean 1·15.

* Mean of three readings.

After being in the Dark.

1	51		1·17
2	59		1·02
3	46		1·304

Average 1·164. Mean 1·1.

colour tests, there have not yet been a sufficient number of tests to lead to any definite conclu-

sion, though in most cases a different reading is obtained. The average for these five persons with white light is 1·236, the mean 1·23; with red, the average is 1·147, mean 1·1; with violet, average 1·206, mean 1·38; with green, average 1·21, mean 1·15.

TABLE IV.—AERIAL GRAPHSCOPE TESTS OF PERSISTENCE OF VISION.
Miscellaneous Group of 11 Persons.

	No. of revolutions per $\frac{1}{2}$ minute.	GIVES	Persistence of vision in seconds.
1. F.	101*		·594
2. M. child	68*		·88
3. F.	96 (long sight)		·625
4. F.	46 (short sight with glasses)		1·304
5. M.	79 (signaller)		·76
6. M.	43		1·39
7. M.	71		·845
8. M.	56		1·07
9. F.	43 (always in perfect health)		1·39
10. M.	77 (with glasses)		·779
11. M.	70		·857

* Mean of three readings.

The first three persons who were tested for colour were also tried after the retinal rest produced by being kept in the dark for some minutes. The first two give a higher reading of persistence than under white light, the third a lower. The average of the group is 1·164, the mean 1·15. No. 1 of Table IV. is remarkable as having taken the highest number of revolutions in the half minute to see persistence, the figure being 101. She described herself as being of good sight. In this list two tests of persons wearing glasses are tabulated: the persistence of one comes out at ·625, the other at ·779.

The question of persistence of vision has an important bearing on modern rapid visual signalling. When I move my hand rapidly backwards and forwards in front of this candle, the flame is alternately hidden from and exposed to view, but you see the candle flame all the time, owing to persistence of vision. Thus, in the same way, a light inside a signaller's lantern is visible, through persistence of vision, when the shutter obscures the actual light from reaching the eye. In reading the signals, the signaller is discriminating between real and incidental images, a rather delicate operation. It seems evident that his sharp reading of — and — will

depend upon the persisting capacity of his retina. Is not, therefore, a good signaller likely to be one whose persistence of vision is abnormally low. According to this theory, No. 1 of Group IV. would be the best signalling. No. 8 represents the reading of a highly-trained signaller, which is ·76.

It would seem that one of the most important tests for a signaller is that of his persistence of vision. But the subject should not only be tested under ordinary circumstances, but under all kinds of conditions, such as after fatigue. Perhaps those only should be selected whose persistence exhibits little fluctuation under a variety of circumstances. For instance, in the fatigue test, No. 4 being ·821 before running and 1·304 after running, would hardly be a fit subject for a signaller. A fitter one would be No. 8, being ·659 before running and ·612 afterwards, combining a low degree of persistency with a not very great divergence under the two circumstances. I think that these figures I have quoted point to the use of the instrument in testing the duration of the persistence of vision, but I consider these tests as only the commencement of the research I have undertaken, and I hope to be able to secure a further number of tests, amongst others, before and after retinal fatigue, and under different climatic conditions, &c., which may be useful and of interest.

Persistence of vision seems also to have an important bearing on art. When artists represent objects in rapid motion, they have to depict effects of persistence of vision, and considering the possible varying effects in different eyes some latitude should be given to artists before condemning their work as unnatural. Persistence of vision plays a part in a galloping horse, the flapping of a bird's wing, and the breaking of waves upon a rocky beach. If our future artists yield to the temptation of studying instantaneous photographs in representing objects in motion their art must suffer unless they do so side by side with the study of persistence of vision with which all objects in motion are clothed. By means of the aerial graphscope, I produce in space an instantaneous photograph of a flight of seagulls. It would be absolutely untrue to paint such positions of the wings for there is no persistence of vision in the photographs, or take the case of this photograph of a wave breaking on the shore. This mass of water does not represent the myriad effects seen when its spray was tossing to and fro. (Illustrations shown.)

To illustrate the value of the aerial graphoscope as an adjunct to the optical lantern, I will throw some specially prepared slides upon the aerial disc. Architectural subjects may be rendered specially effective when freed from the necessity of their being projected on a material screen. If the outlines of the buildings are blacked out on the slides the subjects stand out boldly in relief with pleasing effect. There is also scope for adding effects in the blacked out portion such as moon or clouds. Some natural phenomena subjects are rendered specially attractive when thus treated, such as mock suns and auroras. Astronomical subjects become very realistic when shown in this way. Before you is a very fine photograph of the moon as seen through a large telescope. (Experiments shown.)

I have recently been able to photograph the image produced on the incidental disc by its own light, in this case the camera plate having been made to unite and retain the different parts of the image in place of the retina. Thus we have obtained photographs of an image which does not exist as a whole, and which have a very ghostlike appearance. They are, however, very distinct, and it will be noticed that the real object behind the revolving lath has come out interspersed with the vision. These photographs had an exposure of from 10 to 25 minutes. (Photographs shown.)

To pass to the use of the aerial graphoscope for depicting the supernatural in stage effect, the resources of science are now being largely employed on the stage to add to the interpretation of the drama; but as yet the representation of the supernatural leaves much to be desired, progress in this department of scenic art not having kept pace with the depiction of the "real," which has reached such a high pitch of excellence in our metropolitan theatres. Our leading manager has realised that the conventional method of depicting Banquo's ghost bridges the step between the sublime and the ridiculous, and in a recent production of Macbeth preferred to omit the ghost and leave it to the imagination of the spectators. But the plays of Shakespeare team with possibilities of the weird and artistic representation of the supernatural. This, I venture to think, the aerial graphoscope can supply. It is, in fact, very shortly to be applied for the production of Banquo's ghost in the revival of Macbeth in a Manchester theatre. So simple is the principle

of the revolving lath that it can easily be applied to any scene. The characters where ghosts are to appear can be photographed and their photographs projected from a lantern apparently into space. I have arranged a few special stage effects to show you. The first of these is the aerial, spectral dagger seen by Macbeth, Act I., Scene II., just before he commits the murder of Duncan. I am not aware whether the dagger that Macbeth imagines he sees before him has ever actually been made visible to the audience, but if it is advisable to depict the dagger at all, which is a point for the critics to decide, it can certainly be revealed by the revolving lath with a very spectral effect. (Experiment shown.) Since, in the case of the revolving lath the reflecting surface is so small, the vision produced will stand the full glare of stage light. One of the last actions of the late Sir Augustus Harris a few days before his fatal illness was to experiment with me as to the amount of light such a vision will stand. Not satisfied with a lighted candle which he placed behind the revolving lath, he opened the shutter of his drawing-room window and admitted a beam of sunlight across the field of vision. But the ghost of science, unlike the ghosts of romance, braved out the sunbeam and was plainly visible in its midst.

Another example is the vision of Marguerite seen by Faust on the Walpurgis night. Faust has been taken by Mephistopheles to the summit of the Brocken to witness the revels of the witches' Sabbath, and amidst the hosts of witchery sees the vision of Marguerite, and exclaims, "See you, far off and shadowlike, a fair, pale form?" On the stage the real Marguerite is usually seen in a glare of limelight, hardly fulfilling Goethe's words, "shadowlike." Here, on the other hand, there is a filmy, transparent spectre. (Experiment shown.) In showing you this effect I have arranged the apparatus much as it would be on the stage, the lath and apparatus being hidden from view by this piece of stage property. When the lath revolves, a surface will overlap that is sufficient for the projection of the image. There are other ways of working the invention on the stage; for instance, the shaft that revolves the lath can be suspended by invisible wires and the lath kept always revolving, so as to be invisible. A pretty effect is the Phantom Ship, which would add to the resources in the last scene of Wagner's "Flying Dutchman." (Experiment shown.) Such effects would be an addition to extra-

ganza and pantomime. It may perhaps seem frivolous to mention these lighter forms of entertainment within the precincts of a learned society, but we have all been children once, and many of us, amidst youthful faces, live childhood's days once more. This is my excuse for summoning up from space so grim a vision as the ghosts of Blue Beard's wives.

These are but a few of the experiments and effects that can be produced by the aerial graphoscope, in which the principal agent is a simple lath of wood. The rest has been done by the eye, that instrument you all possess. Beautiful in its outward form, subtle in its movements, brilliant in its colouring, bewildering in its countless expressions, and exquisite in its interior design and workmanship.

DISCUSSION.

The CHAIRMAN, in inviting discussion, said he was reminded while listening to this very instructive paper of the well-known phrase of Helmholtz, that the eye was a very imperfect optical instrument.

Lieut.-Col. STEWART HARRISON said he had devoted some 25 years to the question of visual signalling, and he had no hesitation in saying that this paper marked a distinct epoch in the subject. It gave the information they had all been waiting for, and for want of which thousands of lives and millions of property had been lost. The mercantile marine was absolutely without any means of communication at night, and with only the most contemptible means of communicating by day. Flags, which did very well for their grandfathers, had become entirely obsolete, because, with vessels going 18, 20, and 25 miles an hour, they dragged the flags after them, so it was impossible to see them, except in the two positions, on the beam, or when the flag was blown out the other way. At night, nothing but a few coloured rockets were in use amongst the largest steam vessels in the world, and the result was that no captain could communicate to another at night what he intended to do. He might see a vessel coming full speed on to him, but he was utterly powerless to say that his rudder was broken down, and that he must stay where he was; he could give no warning of any kind. Collisions had occurred both at night and in broad daylight from this simple cause, leading to catastrophes which were positively sickening. When Admiral Colomb began his system, signalling in the British navy was in a state of chaos, but electric communication by cable had been invented and the dot and dash system had been devised. That was seized upon and adopted for visual signalling, with the result that in the army—he knew nothing about

the navy—of 20 selected men sent out for three months training, 17 failed and only three passed; he held in his hand the printed evidence. In a lecture which he delivered at the United Service Institution two or three years ago he stated these facts which had never been contradicted. The signalman's minute was divided into 700 distinct periods; he had to divide it up about $12\frac{1}{2}$ times a second. He had to take 202 impressions of light and darkness, and with such a power of retention in the retina as had been described it was no wonder that these men failed completely. Seven hundred and sixty-four judgments had to be made by each signalman, sent in 16 words of 4 letters each, by the Morse code; 138 states of suspense as to the meaning of the signs as letters, 48 states of suspense as to the meaning of letters as words; 202 light presentations in one minute, and 202 dark intervals. Mr. Bruce had explained why 17 men out of 20, after three months' assiduous practice, were rejected; simply because the retaining power of the retina was too great for the tax upon it. The British admiral who led the world in this matter ought to be called upon for some explanation. They ought to have known these facts for years; but they had been going on with this system at an enormous expense when other systems had been offered them. He would undertake to produce a system which any ordinary man could learn in three days, and which violated none of the conditions which had been so well explained that evening.

Col. KEYSER, C.B., said, as late inspector of signalling in the army, and having been at the head of the signalling department in the Afghan and Egyptian campaigns, he ought to know something about army signalling. Of course they had some failures, when they had a large number of soldiers who came forward promiscuously who had never heard of a dot or dash, but if anyone would watch a body of regimental soldiers signalling they would wonder at the results achieved. They could read by the lamp at night twenty words a minute, and the same with flags by day, only that the labour of moving them was too great to keep up the rate in ordinary usage, though it had been done by way of experiment. It had always been the subject of envy, hatred, and malice amongst official signallers that they could never equal the performances of their telegraphic comrades in the Royal Engineers, but he always told them that visual signalling could not compete with hearing, and after this very instructive paper they could all understand the reason; if the impressions came too rapidly they ran into each other, and became indistinct. For all practical purposes, however, the rate at which army signalling was done (12 words a minute), was fast enough. And within certain limits the faster a message was sent, the more easily could a good signaller read it. Slow signalling was very difficult to read, as the intervals were not so clear. In the war on the frontier the wires were cut every day, and they were absolutely at the mercy of

the heliograph, and they must all do the signallers the justice to say that the work was done very well indeed. He had known of Mr. Bruce's attempts to improve the system for some years, and had had some argument with him about his signalling balloon. He admitted it was a very clever thing, but, as he told him, it was too slow. The only way in which it seemed to him this very instructive paper would bear on signalling was that it might afford a means of testing men for persistence of vision, and so save the instructors a great deal of time and trouble by weeding out men who would necessarily fail in the final examination, not for want of diligence of attention, but simply because they were physically incapable of ever making good signallers.

Col. ALLAN CUNNINGHAM said they had, it appeared to him, been seeing visions of the unseen. It had been beautifully explained that by the imperfection of the human eye, by the necessity which the retina laboured under of preserving, for perhaps a couple of seconds, the picture which had been impressed upon it after the object had been withdrawn, the person saw—it might perhaps be said with the mind's eye—what was no longer before it. The experiments were very beautiful and interesting. He supposed the pictures were really on the plane of the revolving lath, but the architectural views had a wonderful appearance of solidity, and he should be glad if Mr. Bruce could give any further explanation of how that effect was produced. He tried looking at them with one eye, and with both, but it did seem to make any difference. As an old officer once connected with army signalling, he thought the discussion bearing on the practical application of the facts adduced was of the highest interest, and especially the possibility of selecting men whose persistence of vision was very short, seemed full of promise. He thought probably there was something analogous to this persistence in the case of other sensations, such as hearing and feeling; and perhaps, on some future occasion, experiments would be adduced showing that we continued to hear things which had ceased to sound, and to feel things which had ceased to touch us.

The CHAIRMAN, in proposing a vote of thanks to Mr. Bruce, said he did not propose to criticise the paper at all, as it might be looked at from so many standpoints that it would take a long time to discuss it at all satisfactorily. With regard to the question of signalling, however, it was only right to remember, that the functions of seeing, hearing, &c., were performed by the brain from time to time with different degrees of efficiency, and he was not quite sure that any physical test of vision would ever be persistently accurate, even in the same individual. Of course this did not affect the accuracy of the instrument. There was a story of an Irishman who said he could always see better when he had had something to drink. It might be laughed at, but he had experienced the

truth of it when mountaineering, for he found he could see very much better, and persistence of vision could be retained better—whether that were an advantage or not—when he had had a drink than when he was exceedingly thirsty. He might add that it was not necessary that the liquid should be of an alcoholic nature.

The vote of thanks having been carried unanimously,

Mr. BRUCE, in reply, said his system of balloon signalling had been very much improved since Colonel Keyser saw it. The improvement in the filaments of incandescent lamps had considerably progressed since then, and he could now get very fine filaments, which would go out almost instantaneously. He believed when Colonel Keyser saw his signalling balloon he would agree that it approached much nearer the rapidity he desired. At any rate, even if somewhat slow, the signals were not difficult to read, and, at a test in Belgium, not a single message was missed. Perhaps that was because there was a very large body of light, the balloon being lit up from inside by incandescent lamps, and a large body like that was probably more easily distinguished as being in or out than a mere point of light, but on that question there would be a deal of discussion. What he had intended by the paper was not to throw any aspersions on the past, but if they could make things more perfect and assist officers to a better selection of subjects for training, it would be an advantage. With regard to the apparent solidity of some of the views, he thought it was partly owing to the careful blocking out of the outlines. Allowing the light to fall upon it also added to the effect, as it made the outline stand out more in space.

Correspondence.

THE PURIFICATION OF SEWAGE BY BACTERIA.

I am sorry that my friend, Dr. Dupré, should have taken the second paragraph on page 84 (*Journal*, December 17, 1897) of my paper away from its context, as his argument has apparently induced Mr. Roechling and Mr. Kingzett to accentuate what was really far from the idea which I wished to convey. The next sentence, "these introductory remarks on the theory of the bacteriological processes involved," gives the key to my meaning in saying that until recently sewage purification was believed to be simply a process of oxidation. Dr. Dupré's observations in 1885 and 1887 that oxygen alone, in a sterilised sewage, was inactive without the agency of living organisms, in part suggested the paragraph of my paper to which he objects,* as the principle, though proposed so early, has only lately been generally

* *Journal*, December 24, 1897.

recognised, and is still only hesitatingly accepted in certain quarters. When this oxidation is effected in the presence of air, bacteria are the necessary agents while free oxygen is the chief factor required. Nearly all the useful work which has been done on sewage purification has been in this direction only, and very little attention has been paid to the anaerobic changes which also take place before and after oxidation by means of air or (in a less degree) oxidising chemicals. The paper was chiefly directed to showing that important changes do take place other than the well-known oxidation or nitrification effects, which are also due to bacteria, and that these changes are the essential preliminaries to the later destruction. Thus, for example, I consider the formation of carbonic acid and ammonia from urea quite as important as the conversion of ammonia into nitric acid. The former is not "simply a process of oxidation," while the latter is. Similarly, the formation of marsh gas anaerobically tends, undoubtedly, to purify a polluted water; here, again, no oxidation occurs.

Mr. Kingzett's quotations also corroborate what I have contended in my paper, inasmuch as he says that the changes that may be assumed to happen in organic matters when exposed to air are, first, a breaking down, and then further changes induced by the presence of air. I should have preferred to say, "When exposed to organisms the organic matter is first broken down."

In other words, the first changes are effected by the organisms without the oxygen of the air playing any direct part in the changes; whilst the final destruction is brought about by the air directly acting upon the simpler organic matters produced by the first change, through the agency of aerobic organisms.

A third change, I believe, is also of great importance, which follows, under suitable conditions, the oxidation change: this is, the reduction of the nitrates by any residual or organic matter which has escaped the first two processes; this, like the other, is also determined by special organisms.

In all these changes, bacteria, to use the expression of Dr. Dupré, are the "essential agents," but the "chief factor" required is oxygen only when the change is that of nitrification or direct oxidation of the organic matter. Dr. Dupré's essential agents, the two classes of bacteria, are the *personnel* of the purification process, though they are not capable of doing final work without a proper supply of *matériel* in the shape of available oxygen. Both are necessary: the hydrolytic, or first part of the process, I have tried to emphasise.

SAMUEL RIDEAL.

28, Victoria St., Westminster,
Jan. 15, 1898.

Obituary.

SIR POLYDORE DE KEYSER.—Sir Polydore De Keyser died on Friday, the 14th inst., at Cornwall-

mansions, South Kensington, after a long and painful illness from cancer. He was born in Belgium, in 1832, and was for a long time associated with his father, who was an hotel proprietor at Blackfriars. The business eventually attained large proportions, and the Royal Hotel at Blackfriars has for long enjoyed a considerable reputation amongst English and foreign visitors. Mr. De Keyser became an Alderman in 1882, in spite of opposition on the grounds of his being an alien and an innkeeper. He served as Sheriff in 1883, and became Lord Mayor in 1887, being the first Roman Catholic who has held that office since the Reformation. During his year of office as Lord Mayor, he was invited to accept the presidency of the committee which was then being formed to organise the British Section at the Paris Exhibition of 1889, the British Government having, as is well known, declined to take any formal part in it. Mr. De Keyser accepted the office, and took a keen interest in the work, which occupied much of his attention until after the holding of the exhibition. He paid several visits to Paris, where his geniality and his never-failing kindness of heart rendered him very popular amongst all who were associated with the British Section, as well as with the French executive of the exhibition. The success of the section was largely due to his energy, and to the generosity with which he supplied, out of his own private purse, the many calls which would naturally have been provided for out of official funds, had any such funds existed. After the close of the exhibition, his colleagues on the committee presented him with a handsome service of plate, while the French Government recognised the value of his assistance by making him a Commander of the Legion of Honour. He had had some previous experience in exhibition work, for he took a leading part in the successful exhibition of Life-saving Appliances, which was held at Brussels in the year 1876, and it was mainly owing to his efforts that this country was suitably represented at that exhibition. He was knighted after his mayoralty in recognition of his public services. In 1892 he retired, principally on account of increasing deafness, from the Corporation. Sir Polydore was an accomplished linguist, speaking with equal ease French, English, and German, and several other languages, at all events, with facility. He became a member of the Society of Arts in 1876, and served as a vice-president from 1888 to 1889.

General Notes.

PHOTOGRAPHIC EXHIBITION.—The Royal Photographic Society is organising an International Exhibition of Photographic Apparatus and Photographs, which will open at the Crystal Palace on April 27th. In addition to the usual displays of pictures, &c., the leading firms, manufacturers and dealers, will be

largely represented. There will also be extensive loan collections, illustrating not only the history of photography, but its enormous scientific and commercial applications, photo-mechanical processes, photographs in colours, photographs by means of the X-rays, and kindred exhibits. The arrangements for the exhibition are in the hands of a joint committee of members of the society and exhibitors.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock :—

JANUARY 26.—“Fireproof Construction of Domestic Buildings.” By THOMAS POTTER. Sir DOUGLAS STRAIGHT will preside.

FEBRUARY 2.—“The Cinematograph.” By JULES FUERST. CAPTAIN W. DE W. ABNEY, C.B., F.R.S., will preside.

FEBRUARY 9.—“Compensation to Workmen.” By A. D. PROVAND, M.P.

FEBRUARY 16.—“The Protection of Industrial Property.” By J. F. ISELIN, M.A., LL.M.

FEBRUARY 23.—“Children's Sight.” By R. BRUDENELL CARTER, F.R.C.S.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock :—

FEBRUARY 17.—“The Plague in Bombay.” By HERBERT MILLS BIRDWOOD, C.S.I., M.A., LL.D. (late Governor's Council, Bombay). The Right Hon. EARL SPENCER, K.G., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday Afternoons, at 4.30 o'clock :—

FEBRUARY 15.—“The Goldfields of Klondyke and British Columbia.” By W. HAMILTON MERRITT. Sir CHARLES MALCOLM KENNEDY, K.C.M.G., C.B., will preside.

APPLIED ART SECTION.

Tuesday Evenings, at Eight o'clock :—

JANUARY 25.—“Renaissance Woodwork in England.” By J. HUNGERFORD POLLEN. WILLIAM LUSON THOMAS, R.I., will preside.

CANTOR LECTURES.

Monday Evenings, at Eight o'clock :—

CYRIL DAVENPORT, “Decorative Bookbinding.” Three Lectures.

LECTURE I.—JANUARY 24.—The beginnings of bookbinding—Assyrian clay tablets in their cases—Egyptian papyrus rolls—Vellum rolls—Roman diptychs—Mediæval bindings in carved ivory, and metal covers with gems and enamels—Decorative bindings in Europe and the East up to and including the 15th century.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JAN. 24 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Cyril Davenport, “Decorative Bookbinding.” Lecture I.)

Scottish Society of Arts, 117, George-street, Edinburgh, 8 p.m. Mr. D. Bruce Peebles, “Acetylene Gas and a simple Generator for its Production.”

Imperial Institute, South Kensington, 8½ p.m. Mr. C. A. Duff-Miller, “New Brunswick.”

Surveyors, Savoy-street, W.C., 8 p.m. Mr. A. A. Hudson, “Surveyors as Arbitrators.”

British Architects, 9, Conduit-street, W., 8 p.m. Presidential Address and Presentation of Prizes to Students.

Camera Club, Charing-cross-road, W.C., 8½ p.m. Major P. A. Macmahon, “Mirage.”

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m.

Mr. E. Whymper, “My Scrambles among the Alps.”

TUESDAY, JAN. 25 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 4½ p.m. (Applied Art Section.) Mr. J. Hungerford Pollen, “Renaissance Woodwork in England.”

Royal Institution, Albemarle-street, W., 3 p.m.

Professor E. Ray Lankester, “The Simplest Living Things.” (Lecture II.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. W. L. Strange, “Reservoirs with High Earthen Dams in Western India.”

Photographic, 12, Hanover-square, W., 8 p.m. Mr. R. B. Lodge, “The Photography of Bird Life in Spanish and Dutch Marshes.”

Anthropological, 3, Hanover-square, W., 8½ p.m. Annual Meeting.

Colonial Inst., Northumberland-avenue, W.C., 4½ p.m. Mr. L. C. Probyn, “A Gold Standard for the Empire.”

WEDNESDAY, JAN. 26 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Thomas Potter, “Fireproof Construction of Domestic Buildings.”

Geological, Burlington-house, W., 8 p.m. 1. Mr. H. W. Monckton, “Some Gravels of the Bagshot District.” 2. Mr. George Barrow, “The Occurrence of Chloritoid in Kincardineshire.”

Japan Society, 20, Hanover-square, W., 8½ p.m. Conversation.

British Astronomical, University College, W.C., 5 p.m.

THURSDAY, JAN. 27 ... Royal, Burlington-house, W., 4½ p.m. Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 6 p.m. Mr. Frederick A. Cox, “English Secular Vocal Part Music.”

Society for the Encouragement of Arts, 9, Conduit-street, W., 8 p.m. Mr. Alfred Gilbert, “Pre-Raphaelitism in Musical Art.”

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Dewar, “The Halogen Group of Elements.” (Lecture II.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Major-General Webber, “Notes on the Electro-Chemical Treatment of Ores containing the Precious Metals.”

Camera Club, Charing-cross-road, W.C., 8½ p.m. Mr. W. Savile Kent, “Bird and Lizard Life in Australia.”

FRIDAY, JAN. 28 ... Royal Institution, Albemarle-street, 8 p.m. Weekly Meeting. 9 p.m. Prof. C. Lloyd Morgan, “Instinct and Intelligence in Animals.”

Clinical, 20, Hanover-square, W., 8½ p.m.

SATURDAY, JAN. 29 ... Royal Institution, Albemarle-street, W., 3 p.m. Prof. Patrick Geddes, “Cyprus.” (Lecture II.)

Journal of the Society of Arts.

No. 2,358. VOL. XLVI.

FRIDAY, JANUARY 28, 1898.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****CANTOR LECTURES.**

On Monday evening, 24th inst., Mr. CYRIL DAVENPORT delivered the first lecture of his course on "Decorative Bookbinding," which was illustrated by a series of lantern slides of ancient book coverings, specially coloured by Mr. Davenport.

The lectures will be published in the *Journal* during the summer recess.

EXHIBITION OF BOOKBINDINGS.

The Exhibition of Foreign and English Ornamental Bindings was opened on Monday, 24th, and will remain open daily until Monday evening, February 7th. Hours: 10 to 5 p.m., and on the evenings of Mondays and Wednesdays from 6 to 9.

Members can admit their friends by the use of the usual meeting tickets supplied to members. There will be no restriction as to the number of tickets.

Non-members of the Society can obtain cards of admission on application to the Secretary, Society of Arts, John-street, Adelphi, W.C.

Proceedings of the Society.**SEVENTH ORDINARY MEETING.**

Wednesday, January 26, 1898; Sir DOUGLAS STRAIGHT, Member of Council, in the chair.

The following candidates were proposed for election as members of the Society:—

Denny, George A., African City Properties Trust-buildings, Market-street (Room 26), Johannesburg, South Africa.

Parkin, William, The Mount, Sheffield.

Robus, Henry J., Brent-bridge-house, Hendon, N.W. and 20, Bucklersbury, E.C.

Schunke-Hollway, Henry Charles, Plaisir de Merle, P.O. Paarl, Cape Colony.

Scott, Ernest Killburn, Gartmoor-gardens, Wimbledon-park, S.W.

Wackrill, Alfred E., Surveyor-General's Office, Colombo, Ceylon.

The following candidates were balloted for and duly elected Members of the Society:—

Bailey, Hubert Thomas, 4, St. Dunstan's-alley, E.C. Bergne, Sir John Henry Gibbs, K.C.M.G., Foreign-office, S.W.

Bond, Walter George Alick, Holmby, Fortune-green-road, West Hampstead, N.W.

Clarke, Charles Bridger Orme, 4, St. Dunstan's-alley, E.C.

Pitcher, Colonel D. G., Residency Post-office, Gwalior, Central India.

Whinfield, John Henry Richard, 8, Great George-street, S.W., and Brambletye, Cavendish-road, Sutton, Surrey.

Wolfe, Miss Emma Sarah, High Broom, Crowborough, Sussex.

The paper read was—

FIREPROOF CONSTRUCTION OF DOMESTIC BUILDINGS.

BY THOMAS POTTER.

By domestic buildings I mean buildings used wholly or mainly for habitation. Public buildings, where many people congregate, warehouses, and structures containing large quantities of inflammable goods, and other places of a similar character, require greater precautions than are necessary to render domestic buildings practically fireproof, and these time will not permit me to deal with.

The constantly recurring and gradually increasing loss of life and of much valuable property by fire is not realised as it should be; nor, I submit, are sufficient precautions taken to diminish in the future the risk that is now to a great extent easily attainable in the erection of habitable buildings.

The chief officer of the Metropolitan Fire Brigade stated, in his annual report for 1896, that during that year there had been in his district 3,616 fires, more or less of a serious character, to which the brigade had been called; that 106 lives had been lost, besides serious injuries to 110 firemen, of whom two died, and that, in addition, the number of persons injured little or much through fires could not be ascertained.

This is a startling report, and rendered all the more serious when we gather therefrom that our lives, apparently, hang as it were on the result of an occasional spark, or a lighted match carelessly used or thrown away, for 198 fires resulted from the former and 363 from the latter.

The loss of life in travelling and in following dangerous avocations has been lessened in a remarkable degree during the last century. Our forefathers were, we are told, in the habit of making their wills previous to undertaking a journey, by reason of the danger incurred, their homes being considered the safest places. At the present time this order of things is reversed, for, whereas—as just stated—108 persons lost their lives from fire in the metropolis alone in 1896, and in their own homes, only eight passengers met their death from circumstances beyond their own control through travelling on all the railways in Great Britain during the same period.

The serious loss of life from fire in the metropolis would undoubtedly have been increased but for the skilful organisation of the Fire Brigade, and the improvements that have been made of late years in means for checking fires and saving life. If as much care had been bestowed in the past, and was still practised to make our houses fire-resisting as has been expended in extinguishing fires, there would be comparatively but few serious fires at the present time or in the future, so far as domestic buildings are concerned.

We shall be told possibly that many of the houses in which fires take place are old, and that much wood was used in their construction. This is so, but nineteen houses out of every twenty in the course of erection at the present time within the metropolitan area are being built in the same dangerous manner.

The only domestic buildings which the London Building Act compels to be to any extent fire-resisting are those belonging to or occupied by different families, such as hotels and flats, dwellings over stables, buildings used partly for workshops and partly for habitation, and others which are beyond certain dimensions in superficial or cubical area. The great majority of buildings are allowed to be built to burn, except so far as regards external walls, chimneys, party walls, and roof coverings.

The building owner is at liberty to deal with the inside of his house almost as he likes—*i.e.*, he may use wood for floors, partitions, wall linings, stairs, skirtings, roofs, and other things that could be as well formed of incom-

bustible materials and at comparatively little increased cost; these form a standing menace to the occupiers of, at least, the upper stories of every dwelling built in the usual way.

If a certain amount of timber were allotted to be used in the construction of a dwelling-house, and the instructions were that it was to be distributed in a way that, should the window curtains, or carpets, take fire from a spark, a lighted match, or the upsetting of a paraffin lamp, some portion of the timber would be fairly certain to catch alight and the fire to spread with the greatest rapidity, no better arrangement could be devised than the one usually adopted in house building.

As the first step in this direction we have wood joists, about twelve inches apart, reaching from wall to wall over the entire area of the buildings, and resting on wood wall plates; wood floor boards to form a walking surface cross these at right angles on top, and wood plastering laths cross at right angles beneath to form the ceilings of rooms below; a similar arrangement is, as we know, adopted for lighting coal fires in ordinary grates, the crossing and re-crossing and the space between affording excellent facilities for the fire to play round the wood, and air to circulate and so assist combustion. This arrangement, which begins with the ground floor, is repeated every three or four yards in height to the top of the building, where the roof, constructed with wood ceiling joists, wood rafters, and wood ceiling and slate laths, is ready to supply its quota of combustible materials on the slightest provocation.

Wood partitions for dividing the floor area into rooms are often formed of timber quarterings placed twelve inches apart, cross lathed on both sides and affording unusual facilities for carrying the flames upward from floor to floor. Bricks are sometimes built in between the wood uprights, and these to a great extent lessen the danger.

Wood skirtings, dados, match boarding, or wainscoting are fixed round rooms to wood battens nailed to wood plugs, driven into the mortar joints, and sometimes into the chimney flues. A space is usually left between the back of this woodwork and the wall to prevent decay; the air having unchecked circulation through this space, a fire is rapidly communicated from room to room.

Wood stairs commence at the lowest floor and finish at the highest, and it may be said, as a rule, there is practically no disconnection of wood between the bottom floor of a house and the top floor, and no severance or barrier to

check ascending flames; a strong upward current of heated air is provided at the bottom by the well hole of the stairs, and when once the latter are well alight all escape from the upper rooms is cut off, and a leap from the windows or the fire-escape is often the only means of avoiding one or other of the most horrible of deaths, suffocation from smoke or being roasted alive. I have not overdrawn the description of the way houses are being built by the thousand every year, even within the metropolitan area. It was nothing of an unusual character that caused the loss of 106 lives in 1896; it was pretty evenly distributed among 77 different fires, nearly all of which appear to have been in buildings of the domestic class, and almost without exception the fires originated from the most trivial cause.

Another startling statement is to be found in the annual report alluded to, viz., that for the last thirty years the number of fires and the loss of life therefrom have gradually increased; the total number of fires in 1866 was 1,338, 44 lives being lost, as against 3,494 in 1896 and 106 lives lost.

The expression "fireproof" has a conditional meaning; no building can be said to be absolutely fireproof; sufficient time and material for prolonged combustion are all that is necessary to reduce the most fire-resisting building to ruins. It has, however, become usual to designate those buildings fireproof where the materials used in construction are incombustible. Fire-resisting would be more appropriate, but, except in the Building Act, it is seldom used.

The puzzle is why domestic buildings in crowded streets are still allowed to be constructed in a way that may bring death in its worst form to the inmates at any moment and with no warning. There may be a certain amount of prejudice and a corresponding antipathy to anything that savours of novelty, still architects I believe, as a rule, agree that compulsory fireproof construction of a sufficient character to render our domestic buildings of all classes practically safe from fire is only a matter of time, and is a condition with which they have in many instances no sufficient authority to deal.

The only explanation that can be given why fireproofing is comparatively so little adopted at the present time is that the great majority of houses are erected to sell, or to let at an annual rental; building owners desirous of obtaining a large profit on the sale, or high

rate of interest in the shape of rent on their capital outlay, object to spending money for special purposes which are not in evidence on completion, and concerning which purchasers or occupiers appear indifferent, and, as buildings can be insured for their full value, the owner is secured against a monetary loss.

A good deal of misconception exists as to which portions of a house should be rendered fire-resisting, and also an exaggerated notion as to the extra cost.

There is no reason why structures used mainly as dwellings should be built with the same regard to fire-resistance as large shops stored with inflammable goods, warehouses, public buildings, and others used for extensive trade and manufacturing purposes.

An ordinary house in which each apartment is so far fire-resisting that its contents and such structural woodwork as cannot well be dispensed with, or which there is a desire to retain, are together insufficient as combustible materials to spread a fire beyond the limits of the apartment in which it commences, may be said to be practically fireproof.

The external walls of houses are almost without exception compelled to be built of incombustible materials, but the two factors in construction which are the main cause of loss of life by fire in domestic buildings are the wood stairs and the wood floors, and assuming these to be formed of materials that will resist a moderate fire for a couple of hours at most, the skirtings, doors, door surroundings, windows, fittings, carpets, curtains, and furniture combined would not in themselves be a source of much danger beyond the apartment containing them, and may therefore be considered as factors of secondary importance in connection with fire resistance.

But so far as regards skirtings they would always be better if constructed with Portland, Keene's, or Parian cement, because in connection with the wood architraves of doors, skirtings form an almost and in some cases entirely unbroken line of woodwork from end to end of corridors and passages and round all rooms, and along which fire may possibly travel.

There is no objection to cement skirtings that I am aware of, except that they cost somewhat more than wood; they are far more durable, solid, not readily damaged and non-absorbent, and even on sanitary grounds alone should, I submit, become more general than is the case. Stairs should be of concrete, stone is unreliable; the collapse of stone stairs when exposed to a severe fire has occurred on

several occasions. The cost of concrete stairs is more than wood stairs, but unless they are of intricate design it is by no means a serious item. The construction of concrete stairs was well known to both Romans and Normans, and specimens of their work are still in existence.

Concrete stairs are constructed by casting each step in a mould, or by casting the whole flight *in situ*, and the principle of construction is now well understood. The best materials for concrete stairs, both for strength and fire resistance, are Portland cement and crushed bricks—fire-brick by preference—clinker from furnaces or slag from iron ore. Oak and other hard wood stairs of a defined thickness are classed as fire-resisting under the London Building Act, but given sufficient fire they add fuel to the flames. Wainscoting, dados, and wood cornices can be entirely dispensed with where protection from fire is of paramount importance, or if necessary formed with cement. Wood liftings and boxing shutters can well give way to revolving shutters of steel or hard wood. There is but trifling danger in the latter because the amount of wood required is so small that it need scarcely be taken into account. Considering the neatness and efficacy of revolving shutters it is strange they should not be more generally adopted for houses where shutters are considered necessary, especially as the cost is less than the ponderous boxing shutters. The woodwork necessary for the windows of a room is scarcely likely to take fire except under provocation, but it appears that curtains and window blinds are often the cause of an outbreak through a lighted lamp or candle being upset or placed near thereto. In ordinary sashes or casements there is but little wood to burn, in the frames there is somewhat more. The portions of sash frames more exposed than others are the inside linings, pulley stiles, heads and cills, and if these were made of teak, which would resist any moderate fire after the paint on the surface had burned away, another element of danger would be avoided. The extra cost would be, possibly, from 8s. to 15s. per window, according to size.

Architraves to doors and windows, and window-jambs or linings can be formed of cement at a somewhat increased cost, where the use of wood is not desirable, but door-jambs, doors, windows, and fittings, such as cupboards, dressers, linen-presses, shelving and the like, must apparently still be of wood, for there is no other material that I am aware of which serves the purpose equally as well

for habitable buildings. The wood I have just named in an ordinary building is classed under the general term of joinery, and is mainly exposed to view. But the dangerous factor in a building is the hidden timber which is of much greater proportion, and being practically out of sight, may smoulder and burst into flames without any previous warning whatever.

Under this head we get floor-joists, partitions, wall-plates, templates, lintels, roof-timbers, occasionally wood battening fixed against brick walls for lathing thereto, or for match boarding.

It is common knowledge to everyone engaged in building operations, that all these can be dispensed with, and incombustible materials substituted with no more trouble, but at some increase of cost, and the latter is the crux of the whole matter. In place of partitions formed of wood and lath and plaster, they can now be constructed in various ways of materials that will not burn, such as iron uprights, metallic lathing, and ordinary plaster—solid plaster with iron rods embedded therein—fire-proof blocks, breeze concrete, and other materials, all of which are light and fire-resisting. Fire-proof coke-breeze lintels, in which small metal tension rods are embedded, for use internally over doors and windows, are readily obtainable. Coke-breeze blocks or bricks to insert in walls for fixing joinery thereto, are in every way preferable to and better than wood, and if new or old walls require to be battened for plaster, as is practised in external walls of some seaside houses to prevent rain from penetrating, metallic lathing can be fixed to metal lathing bars secured by galvanised wall hooks. Externally, the roof is the dangerous factor in construction; where barge boards, dormer windows, and skylight frames are in evidence, danger exists if a fire is in progress in the neighbourhood through sparks being carried by the wind.

Under the old Building Act, windows had to be set back at least $4\frac{1}{2}$ inches from the face of any wall, but now they may be flush therewith. All the outside wood window linings in this arrangement can now be exposed; under the old Act they were almost entirely out of harm's way in the brickwork reveal.

Fireproof roofs are obviously more difficult to construct than the usual wood type, except a flat form is substituted, and although objections may be made to flat roofs for country houses and suburban villas on the ground of appearance, there can be but few reasons why they should not be adopted in towns.

In addition to safety from fire, flat roofs do away with the great danger in towns arising from tiles and slates being deposited on the heads of foot passengers during high winds; they also save the annual recurring cost of tile and slate repairs, and the danger of flooding from choked lead gutters and down pipes. They have other advantages in connection with workmen's flats and similar buildings where the laundry is on the top floor, in being available for drying-places, and there is no reason why flower beds and gardens should not be established thereon, a proposition made by the late Dr. Richardson. On a very high flat roof within a few minutes of the Mansion House, excellent grapes are grown in a small artificially heated vinery.

Flat roofs are usually constructed in much the same way as fireproof floors, but laid to a slight inclination to carry rain-water away into the stack pipes, and covered with the best mineral asphalt. Concrete and cement alone, with the greatest care, will not form a watertight roof.

A roof of this description should be more durable than others, and entirely avoid the necessity of repairs for almost an indefinite period. The cost, too, would in many positions not exceed that of the ordinary slate or tile roof, lead gutters and other accessories taken into account, while, as regards security from fire, not a particle of wood need enter into the construction.

Fireproof roofs are being adopted for some buildings, but by far the great minority, and but little difference of opinion exists as to what materials should be used and how they should be applied; but a fireproof roof is of no avail if the floors are constructed of wood, and when we come to fireproof floors we have to deal with a factor in construction upon which opinion differs to a very great extent; as a result, except where Building Acts and by-laws compel their adoption, they are, comparatively speaking, but little used. The reasons for this are many. By some persons they are supposed to take up much more space than wood; that even if covered with wood they are still cold to walk upon; that the weight is excessive; that they conduct sound more readily than wood, and other objections which do not, or need not exist: but the principal one is, as in so many other matters connected with the erection of new buildings—cost. They are regarded as a “luxury” in construction, and when estimates have to be reduced it is often the case that the first

thing to go (if the Building Act permits) is the fireproof floors.

We have heard of many wide estimates as to the cost of fireproof construction above that of ordinary construction, ranging from 10 to 50 per cent. of the cost of the building. It is quite certain that there will always be a considerable difference in the ratio of cost, for a building with no pretensions to internal decoration or external architecture, such as workmen's flats, requires equally as much flooring as a mansion costing twice as much but of the same size. Taking average buildings of moderate pretensions, I think it will be found that wood floors complete, including the wood lathing for ceilings, cost on an average about 5 to 7½ per cent. of the total outlay, and that fireproof floors average about double that of wood floors. Assuming therefore that a house costs £2,000 to build, and is of the annual value of £150, the fireproof floors at the very utmost should work out at a cost not exceeding £150 in excess of wood floors, and this at 5 per cent. would increase the rent by £7 10s. a year. Fireproof roofs, as I have said, cost but little more than the usual kind, and the extra expenditure on stairs and all the other details of construction which I have enumerated, except architraves to doors, which are unnecessary to be of cement, would be well covered by another £150; so that for £15 a year, at most, increase of rental on a house of the estimated annual value of £150, the owner would gain by having fewer repairs to pay for, and the tenant would gain by reason of its healthfulness, freedom from insects and vermin, and security against fire.

If a large reduction of fire insurance premium on both house and its contents was obtainable—and it ought to be through danger from fire being almost *nil*—there should be practically very little increased rental necessary.

On hygienic grounds, I submit that fireproof floors have not received the consideration they should do. The space between the floor boards and ceiling of the usual type of wood floor is a receptacle for the dirt and dust of generations, and in the majority of houses a refuge for rats, mice, beetles, and other domestic pests.

Floor boards may be grooved and tongued, but the floor sweepings and floor washings together convey the fine dust through the joints of the floor boards of ordinary houses, let them be ever so closely fitted when first laid.

In external walls of buildings it is sometimes the practice to insert ventilating bricks to admit air to the floor timbers, with a view to

prevent their decay. Where the floor boards have shrank or been badly laid, an imperceptible current of air to the room above is the result, bringing with it a return of some portion of the impalpable dust that has found its way beneath the floor, and the housewife wonders where all the dust on her furniture comes from.

If the floor timbers acquire dry rot—by no means an uncommon occurrence, even in well-built houses, the initial stage often developing before wood leaves the docks—a rank fungus is the result, which spreads with alarming rapidity and is in a high degree dangerous to health,

If the space between floors and ceilings of many houses, even of a superior class, erected say twenty to fifty years since, could be exposed to view, a condition of affairs would be revealed that would lead more surely to the disuse of wood floors than any description or any amount of persuasion can effect.

It must be conceded that fireproof floors are to some extent a costly item in a building; on the other hand, it is my object to convince you that no building is reasonably safe which has wood floors and stairs, and that, on hygienic grounds alone, fireproof floors are worth the extra cost, even where cost is the paramount factor in construction. Very much less is known in a general way about fireproof floors than about most other details of building construction, and they do not possess any attractive features whatever.

The Romans formed them of brick and concrete, the latter as much as 20 feet span, with no intermediate supports, and specimens of their concrete floors still exist in various places, but, so far as I know, nothing of a fireproof character, except brick arches, which were confined to basements and underground rooms where injury from outward thrust could be guarded against, was attempted in this country until quite modern times.

This is to be accounted for by reason of suitable materials for the purpose being practically unknown a century ago. Portland cement had not been discovered, rolled iron and steel were unknown, and concrete itself—so well understood by the Romans—was not in use in this country even for foundations.

In 1775, a patent was granted to Mr. Hartley for fireproofing wood in buildings, by nailing thin iron sheets round floor joists and other timbers, and Parliament voted a sum of money to continue the experiments; but the result was a failure, and, a little later, Earl

Stanhope proposed to fill in between wood joists with rough mortar laid on wood laths—what is known as pugging, and used at the present time not so much with the object of making floors fireproof as to prevent sound from passing through.

Since then, I believe I am correct in saying, Parliament has made no further grants for a similar object.

Spasmodic attempts were made subsequent to Mr. Hartley's scheme, but they were all more or less unsuccessful.

Sir William Fairbairn in his book, "The Application of Cast and Wrought Iron Work to Buildings," says the first instance of the successful application of cast-iron beams for the fireproof floors of a building, was for a cotton mill erected in 1801 (Fig. 1); the ironwork was designed by Messrs. Boulton and Watt, the cast-iron columns being entirely unprotected.

Up to 1844, numerous patents had been taken out for fireproof floors, but none came to stay until Dr. Fox introduced what was afterwards known as Fox and Barrett's floor (Barrett being the business partner), and this was in use until quite recent years. Dr. Fox had, no doubt, as medical officer of a large lunatic asylum, become aware of the frightful consequences that might result in case of a fire breaking out in a building where a large number of insane patients were confined. Fox and Barrett's floor was very popular in London and elsewhere for many years.

Fig. 2 is Fox and Barrett's floor; A A, small cast-iron joists or girders; B, strips of wood, $1\frac{1}{2}$ inch square, resting on the bottom flanges of joists and spaced half an inch apart; C, a coat of rough plastering mortar partially squeezed through between the wood strips; D, pugging; E, cement mortar; F, mortar made of two parts of sand and one of hydraulic lime, trowelled off to form a walking surface.

Mr. Wilkinson, of Newcastle, patented several varieties of floors in 1854 and later dates; one was formed with brick arches and concrete over; another was a flat arch section of Portland cement concrete, the latter possibly the forerunner of concrete arches of considerable span.

Bunnett's floor, introduced in 1858, was at that time of novel construction, viz., hollow interlocking burnt clay blocks or bricks joggling or keying each other at the joints. Fig. 3 is a section of Bunnett's floor. This principle has been practised in a variety of ways in America, but does not as yet find

much favour in this country. The under side of the blocks have a dovetail groove to afford a

Dennett's floor, introduced in 1857, is another that has been used to a very great

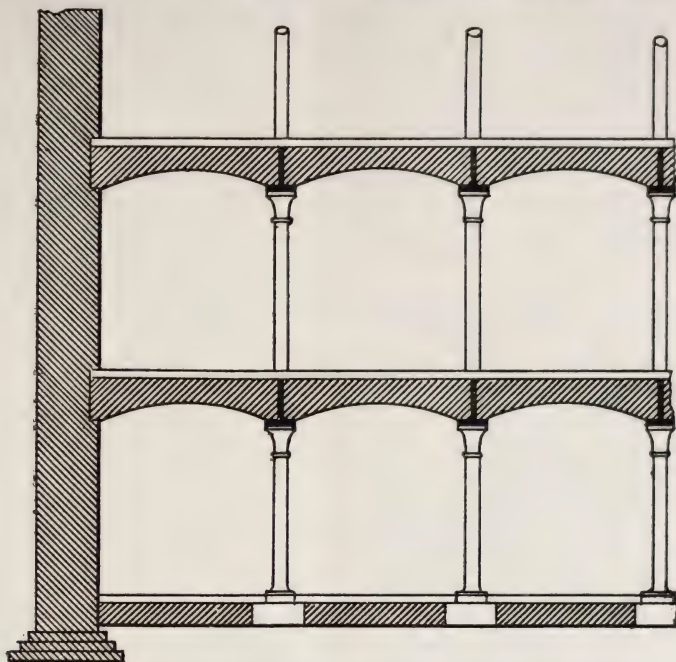


FIG. 1.—FIREPROOF FLOOR, 1801.



FIG. 2.—FOX AND BARRETT'S FLOOR.

key for the plaster, as shown, an idea which has since then been claimed as part of

extent. Originally it was made with plaster of Paris as the cementitious ingredient, and con-

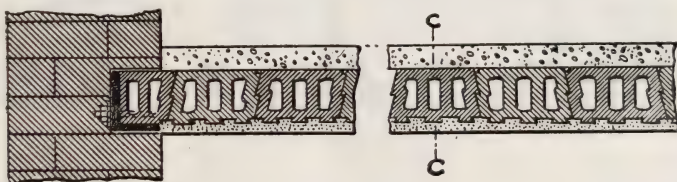


FIG. 3.—SECTION OF BUNNETT'S FLOOR.



FIG. 4.—HORNBLLOWER'S FLOOR.

numerous floor patents. The floors of the Grosvenor Hotel at Pimlico are Bunnett's.

sisted of segmental arches up to 17 feet span, and cast-iron beams. Subsequently Dennett

introduced various improvements. All the floors of St. Thomas's Hospital are Dennett's.

Matthew Allen, a builder of Finsbury, brought out fireproof floors in 1862, consisting of bars of iron 3 inches by $\frac{3}{4}$ -inch, laid edgewise across the building from front to back, and 2 feet apart; through these $\frac{1}{2}$ -inch iron rods, also 2 feet apart, were passed and secured to the bars at the ends. A temporary scaffold was fixed beneath and cement concrete was thrown in to a thickness of 4 inches. The floors of the Waterlow model dwellings in Finsbury are executed in this way.

Mr. Hornblower, an architect of Liverpool, in 1873 recognised the danger of exposing iron beams to fire, and devised an ingenious arrangement of encasing them entirely with burnt clay or terra cotta, as shown in Fig. 4, A A are rolled iron girders; B, pottery ware tubes; E, fine concrete at top. Hornblower's floor was used for the Liverpool Corn Exchange and many other buildings. Previous to this Hornblower had employed clay tubes, or pipes, resting on the bottom flanges of the joists, covering the latter on the under side with an inch in thickness or more of concrete, a mistake which was soon rectified by others, as shown in Swarbrick's fire-clay lintel floors (Fig. 5), A, rolled iron joist; B, earthenware lintels; E, projection to protect bottom flange of joists; D, lip to give the slab strength; H, wood joist and floor. In Hornblower's tubes, Swarbrick's slotted lintels, and Bunnett's dovetail grooves we can trace the origin of tubular lintels for fire-resisting floors as used at the present time.

in use now, which may be better or worse for all I know than the 190 others not shown.

It was suggested at one time that solid wood floors would resist combustion and possess many advantages over steel and concrete. The principle proposed was to form them with deals or battens edgewise and fixed close together. This system has been practised in America, but in a paper read lately by Mr. W. L. B. Mudie, an architect of Chicago, the author said that this principle of slow burning floors was not justified by experience, for when once a building got well alight they made a terribly intense fire. Oak is always assumed to be fire-resisting to a high degree, but Mr. E. C. Shankland, lately stated that 80,000 feet—superficial feet, probably—of oak timber was piled in a new building for the Chicago Athletic Club, and while the building was in progress a fire took place and the whole of the oak was destroyed. Silicate cotton and asbestos have both been suggested for packing between and around all hidden timbers, but the dangerous factor wood is still in existence, only waiting for a loophole to prove how difficult it is to make a building fire-resisting, but there can be no doubt that both silicate cotton and asbestos afford very great protection.

But, with all their disadvantages, I believe it is pretty well agreed that steel beams and joists and Portland cement concrete, or clay tiles or lintels in combination, judiciously treated, are up to the present time the best materials we know of for forming fireproof floors, although in the United States steel

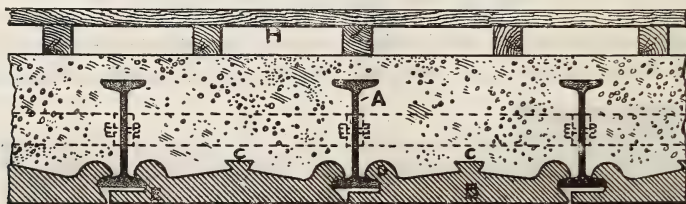


FIG. 5.—SWARBRICK'S FLOOR.

But during the last twenty years many varieties of fireproof floor have been introduced, over 200 patents having been applied for in this country alone, but the comparatively few that have been used to any extent are divisible into not more than four types. I am not going to suggest that patent floors shown here are superior to others; they are simply shown as illustrations of floors in the early history of fireproof construction, and of types of others

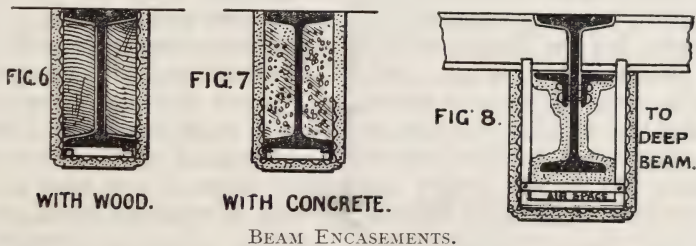
beams and porous terra cotta are more in favour. Flat slab floors of concrete, as Fig. 9, without beams of any kind, simply resting on the walls, have been advocated and adopted to a very limited extent; then, we have steel joists fixed certain distances apart, three to six feet usually, and concrete filled in between level with the top flange and an inch or so below the bottom flange, as Fig. 10—other types of floors consist in embedding iron or

steel in the concrete when in a soft state; then we have arched formed floors and level ceilings as Fig. 11, and lintel floors consisting of clay lintels resting on the bottom flanges of beams or joists, and concrete filled in over as Fig. 14 and 15.

But in selecting one or other of the systems named, or of any other form of construction, the properties of the materials to be employed should be the first consideration.

It is well known that steel beams and joists expand and buckle when exposed to heat, and that in a high temperature the loss of strength is also considerable. These are two disadvantages that can only be remedied in one way, and that is by so protecting them that it shall not be possible in domestic buildings for a fire of one or two hours duration to injure them. By beams I mean deep single sections, or two or more sections of rolled steel forming compound beams, or rivetted plate girders to carry smaller sections which I call joists, the terms being synonymous with those used in wood-floor construction. Where beams are used a portion usually projects below the ceiling line, and have, therefore, a much larger superficial area needing protection than the joists; moreover, they support a large portion of the entire floor, and should therefore have the greatest possible protection; but instead of this, so far as my observation goes, the usual custom is to wedge light pieces of wood between the top and bottom flanges, about a foot apart, flush with the outside edges of the flanges; to these metallic lathing is nailed, as Fig. 6, and this

this way more than three inches thick; it is difficult to apply it in a soft state, and it is moreover a moderately good conductor of heat, and more important than all the bottom flange of beam is either insufficiently protected or not protected at all. On the other hand, plastering mortar possesses little more than one third the conductivity of brick or tile, and if applied so as to leave a hollow space behind, an inch and a quarter in thickness of plaster is more effective than two and a-half inches of concrete. I am told that asbestic plaster has much less conductivity than common plaster. Sir Eyre Shaw, the former chief of the Metropolitan Fire Brigade, wrote some years since in reply to an inquiry, "Very little plaster will suffice to prevent ironwork from melting, softening or cracking, if only it remains on, but this is the difficulty. Some key is absolutely necessary, and hoop iron or wire netting would probably be found the cheapest and best; with a really trustworthy key about half an inch of plaster would ensure safety." When Sir Eyre Shaw wrote this, metallic lathing had not come into use. To ascertain for myself the capability of common plastering to resist fire I built a small brick enclosure seven feet square and six feet high, upon the top of which I laid steel joists and attached thereto a suspended ceiling on expanded metal lathing. When the plaster was thoroughly dry I made a larger fire under than would be likely to occur in an ordinary room, and after two hours of fierce combustion and repeated quenching the upper side of the ceiling with buckets of water, the



BEAM ENCASEMENTS.

is plastered in the usual way. When the wood blocks become so hot that combustion ensues, the lath and plaster must inevitably come away, and the beam being exposed it is almost bound to collapse.

The London Building Act permits this arrangement, I believe, in any building. Concrete is sometimes filled in between the top and bottom flanges and metallic lathing fixed thereto and under the bottom flange, as Fig. 7, but it is seldom practical to employ concrete in

plastering remained sound, although pieces of wood an inch thick thrown on the top of the ceiling were ablaze in a few seconds from the heat conveyed through the plaster. I am bound to say the result was quite a surprise to me.

The steel joists, although unprotected, were not injured to an extent that would cause them to buckle or expand to any degree, and nearly one hour after the fire was lighted they were but moderately hot.

A further protection may, I suggest, be practised by plastering the flanges and exposed portions of the beam with asbestic plaster, which I believe adheres better to unpainted metal than to painted.

The diagram, Fig. 8, shows light stirrups, A, made from $\frac{3}{4}$ by $\frac{1}{4}$ in. iron, going round the beam, B, suspended to the angle bearer, C, and fixed 12 in. apart; a lighter bar, D, is rivetted across the bottom to grip the plastering, E—asbestic is preferred—on the bottom flange as an additional precaution in case of fire to prevent it from falling away. The asbestic on metallic lathing, F, is in this way clear of contact with any portion of the metal. I am unable to speak from experience as to the merits of asbestic, but if the reports concerning it are true, it has some marvellous properties in connection with fireproofing, as regards resistance both to fire and water. Protected in this form I am strongly of opinion that beams would withstand greater heat than if encased with concrete or terra cotta or fireclay tiles, say 2 in. thick, as the outer plaster encasement is everywhere disconnected from the beam itself, and forms a valuable and almost invulnerable first line of defence.

Doubt has been expressed whether the heated air between the plastering and the beam would not expand and burst the encasement. I suggest that this can be avoided by fixing an air brick or tube in the walls upon which the beams rest; anyway, it should not be a difficult point to deal with.

Joists in almost every system have their webs encased by the floor materials; the top flanges are much less liable to become overheated than any other portions, but the bottom flanges require greater protection than any other part, as they are at all times subject to a severe tensile strain, and in case of fire the heat is directed full against them. No floor is absolutely safe unless the bottom flanges are efficiently safeguarded. Sir Nathaniel Barnaby in making experiments in connection with iron ships found that iron and steel beams gained in strength up to between 490° and 550° Fahrenheit; beyond this their strength rapidly diminished.

The expansion of steel at 500° is an inch in 28 feet Fahrenheit, and at 1,000° an inch in 14 feet. Iron when dull red-hot is 1,300°. The moral to be derived from these figures is that if the steel beams and joists used in fireproof floors can be so far protected that they do not attain over 500° of heat, there is but little harm either from loss of strength, heat, or expansion.

Where beams have to be employed I think it is only reasonable they should be no longer than is absolutely necessary, *i.e.*, they should be disconnected at every bearing where possible.

Divided opinions prevail as to whether concrete is reliable as a fire-resisting material or the reverse; this depends mainly upon the materials of which the concrete is made. Thames ballast is one of the worst, and being used at one time for fireproof floors in London, many failures took place, and firemen were cautioned not to enter burning buildings which possessed fireproof floors.

The most reliable fire-resisting materials are crushed bricks, coke breeze, clinker from furnaces, slag from iron ore, pumice and similar substances which have passed through fire. Mr. Webster's experiments proved that slag made the strongest concrete, broken fire-brick came next, and then pumice, while coke breeze was the weakest, but after being heated to a red heat, and quenched with water, the order of things was reversed, for it was found that slag had lost two-thirds of its strength, broken fire-brick nearly as much, pumice about the same, but coke breeze less than one-half, and that the latter was then stronger than the other three materials. Neat cement was only about one-fifth its original strength after being heated and quenched, but it was clear that when diffused among other materials to form concrete, its strength from some cause or other was not diminished in the same ratio. But good concrete increases in strength with age, and assuming that a concrete floor will sustain the specified load required at a month, it should carry double that at a year, and from this we gather that if a concrete floor made of coke breeze is exposed to a fire, and becomes nearly red hot—say 1,000° Fahrenheit—it ought to be still capable when cold of supporting its original specified load, subject to not being weakened from other causes, and here another contingency arises, expansion from heat and subsequent contraction, for coke breeze expands about three quarters of an inch in 28 feet at 1,000° of heat, and crushed bricks one inch in 28 feet. This appears to be a substantial objection to the use of floors formed of a single slab without joists, or of large self-supporting areas of concrete for floors, whether flat or arched. So far as regards strength, first-class concrete requires no steel beams or joists whatever for floors up to 15 feet between supports, nor any iron embedded therein. I have, many years since, executed 12 feet spans of a uniform thickness,

as shown by Fig. 9, of $4\frac{1}{2}$ inches only, but the effect of a fire would be to cause them to expand, and as they cooled to contract and, probably through being tied into the walls so as to be unable to adjust themselves to circumstances, they would break up into fragments.

cracks may not develop for a year or more after the floor has been completed, and if they are covered on the top with a wood-casing, and the under side is plastered, they may never be visible. Then another objection to slab floors is that the lower half, or half below the neutral

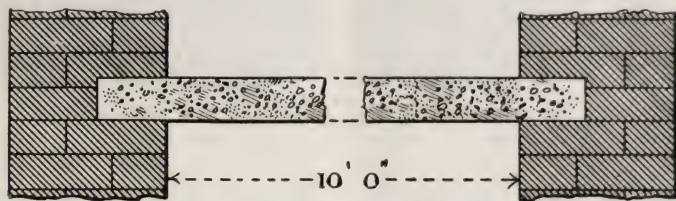


FIG. 9.—SLAB OR PLATE FLOOR.

Concrete paths in public streets expand and contract with ordinary variation of temperature, and to avoid irregular cracks are executed, as we know, in sections of about 9 feet square.

But as the temperature in a house fire scarcely exceeds, we are told, $1,000^{\circ}$, there should be no difficulty in so protecting the beams, the joists, and the concrete, that neither should in an ordinary house be exposed to a temperature of more than 500° one hour or longer after a fire has got well alight.

Cement concrete has some peculiar properties, for instance, it is not considered by any means an elastic material, but I have seen a slab 10 ft. in length and $4\frac{1}{2}$ in. in thickness deflect over an inch in the centre under a heavy load and resume its original shape within a quarter of an inch, after having been weighted for several days. So that any perceptible movement or deflection of a concrete floor in walking over or jumping upon it, does not necessarily imply danger. This is, however, not a pleasant sensation when the floor is known to be of concrete, and to avoid this a flat floor has to be thicker than is absolutely necessary for strength. A segmental arch-shaped floor, as Fig. 12, an advantage in this respect, for no matter how light it may be it is practically rigid.

A flat slab floor without joists has another disadvantage, viz., the effect of ordinary changes of temperature, as before described. The difference of temperature in the rooms of a dwelling is never very great, but combined with the tensile strain on the lower half of the floor, it is sufficient to cause slight cracks in the concrete on the under side, as the result of a change from heat to cold, and, although I have never known an accident result therefrom, cracks are naturally looked upon, and with good cause, as signs of danger. These

axis, is undergoing a tensile strain, a strain which concrete is least liable to resist, and these combined disadvantages go to prove that although flat floors of concrete without any joists are economical in cost and space, they are not adapted for rooms of domestic buildings. They may do very well for corridors, passages, lavatories, and the like, always remembering that concrete conveys sound more readily than any other building material; as an instance, conversation carried on in an ordinary tone in a room divided from another by a 6-inch concrete partition, plastered on both sides, can be heard in the adjoining room; this I state from experience.

Another type of floor is the same as the one just described, but has steel or iron rods, wire netting, expanded metal, or any other form of steel or iron embedded in the concrete below the neutral axis, for the purpose of counteracting the tensile strain. Floors of this character have been advocated for years, more especially those of Hyatt, Brannon, Monier, Edwards, the Expanded Metal Company, and several others. The main point is to prevent shearing of the embedded material, and this is usually obtained by securing the ends of the metal ties in the concrete. The strength of concrete floors is largely increased this way, but the general disadvantages of the slab floor, just described, are still the same, and if large areas of concrete have to be divided into smaller by means of steel joists, I fail to see much advantage in the use of embedded metal.

The so-called solid concrete floor (Fig. 10) is more largely used than any other, principally because it costs less, can be executed by the builder, and came into use at a time previous to the general introduction of better systems.

Joists are usually fixed 2 to 6 feet apart according to circumstances, and the concrete kept an inch below the bottom flange with the object of protecting the beam from fire, and a plaster ceiling is formed on the concrete.

being simply jagged or indented with a pointed tool, and in case of fire the plastering will possibly soon fall away, indeed this often occurs without a fire.

The weight of a concrete floor of this kind,



FIG. 10.—SOLID CONCRETE FLOOR.

The objections to this form of floor, from my point of view, are—(1) that the one-half portion of concrete below the neutral axis is of little use so far as regards strength; (2) it conveys sound very distinctly; (3) the concrete having to be of a thickness equal to the depth of joist, plus the inch below, is very heavy; (5) in case of fire the under portion may become very hot before the heat reaches the upper

as shown, nine inches in thickness, is about 40 lbs. to 50 lbs. per superficial foot, without the joists, while the greatest live load necessary to be provided for floors of domestic buildings is said to be only between 20 lbs. and 30 lbs. at most. A modification of this floor so as to reduce the weight of concrete, as shown by Fig. 11, was adopted some years ago, but can scarcely be called a fireproof

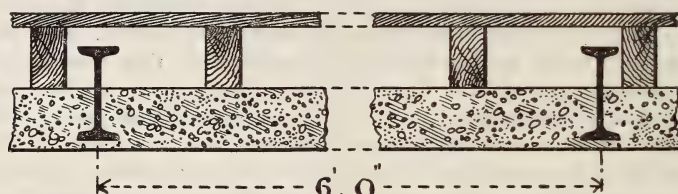


FIG. 11.—FIREPROOF CEILING.

portion; owing to the thickness it has to permeate, expansion in some places and none in others creates rupture of the particles, and, cohesion being weakened, masses may fall away, or if expansion occurs from heat, rupture of the concrete will take place at its weakest point, and that is where it encases the bottom flanges of the joists, where it is only an inch in thickness; should this happen, and the fire is

floor, a better title would be an improved wood floor.

I mentioned that these are a description of floors usually performed by any kind of labourers. My experience is that workmen who have acquired an intimate knowledge of concrete floors, and take an interest in their work, perform it in a superior way, produce better work, and are more reliable.

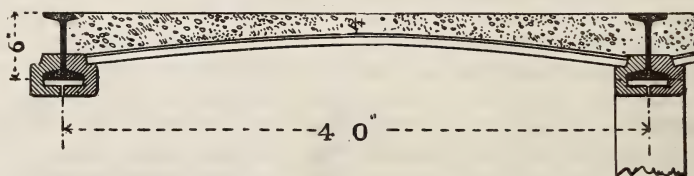


FIG. 12.—ARCH-SHAPED FLOOR.

extensive, the fate of the floor is settled, although in an ordinary way it should scarcely be sufficient for this; (5) plastering on concrete surfaces of this character to form ceilings has scarcely any key, the concrete surface

Concrete floors which have collapsed were, so far as my knowledge goes, done by men of no experience, notably one at Portsmouth in 1876, which fell and killed four men, although the concrete was twelve inches in thickness,

and sufficient in quantity for at least two floors of the same area capable of supporting 2 cwt. per foot super., the distance between supports being only 8 feet. In his report as to the fall of flat concrete floors at Cambridge in 1878, Mr. Baldwin Latham says, "I am decidedly of opinion that concrete for the floors of a building is one of the best materials that can be applied, but the material should be cambered so that the strain may be in compression and not in tension." But there is an impression that concrete floors of an arch form exercise considerable thrust, and must necessarily be held together by tie-rods and bolts, but, except in large spans, this is not so. Fig. 12 shows a concrete arch 5 feet between supports, 1 $\frac{3}{4}$ inches thick at the crown and 5 inches at the haunches, loaded with 4 cwt. per superficial foot, and resting only on wood posts, and the deflection in the centre is but very slight.

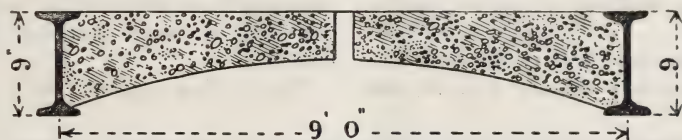


FIG. 13.—FLOOR EXPERIMENTS.

Fig. 13 shows two beams, 9 inches by 4 $\frac{1}{2}$ inches, between which a concrete arch on wood centering, made from broken bricks, was formed, 9 feet between the beams and 4 $\frac{1}{2}$ inches in the crown. After an interval of a month the centering was removed, a piece of concrete an inch in width sawn out of the crown, and the surface loaded with about 80 lbs. per superficial foot without any sensible change of form, and this, I submit, goes to prove that arch-shaped concrete assumes more the character of a cantilever than an arch. But level ceilings are necessary for rooms of dwelling-houses; this can be obtained by forming them of metallic lathing suspended to the joists, while the vacant space that intervenes creates a barrier to the transmission of sound.

Fawcett's floor, Fig. 14, and Homan's floors,

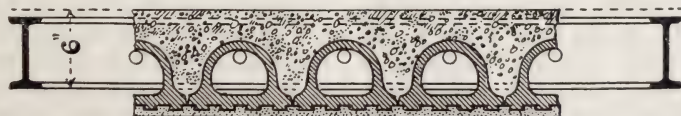


FIG. 14.—FAWCETT'S FLOOR.

Fig. 15, are too well known to require any description; they are types of the lintel form of construction, with a portion going under to protect the bottom flanges. Concrete is filled

in up to the level of top of joists, and the under sides of the lintols are plastered in the usual way. There are numerous floors of the lintel type—Willis and Astley's, Pickering's, Fergusson's, and others. I offer no opinion as to the relative merits of any patent floors in use. Were I to do so impartially I could only say that probably they will all safely support any reasonable load; that their cost is very much the same; that each may possibly possess some advantage, more or less, over others; but until a series of tests have been made as to fire-resisting and other desirable properties of some of the best types of floors by some independent authority under similar conditions, and upon areas of suitable dimensions, no comparative results are possible. The patentee of every floor can bring ample evidence, without doubt, to prove that his system is far better than any other, and also that the severe trial

it has withstood against fire in a small test place 7 or 8 feet square, arranged for the purpose, has beaten all previous records; all the same, it is quite a different thing from a fire in an apartment 18 or 20 feet each way, and not specially constructed to be tested.

My views as to fireproof floors for domestic buildings are:—

1. Steel beams should be avoided as far as possible; up to 24 feet span, or between bearings, they can be dispensed with altogether, and joists of moderate size substituted at but little increase of cost.

2. Where, however, steel beams are necessary the greatest care should be taken to protect them from fire.

3. Steel joists to divide floors, whether flat or arched, should not be more than 6 feet apart,

and should also be well protected, more especially the bottom flanges, which as a rule are less cared for than other portions; the top flanges are not so important.

4. A better quality of concrete, and less of it than is usual, should be employed to lessen the enormous weight thrown upon walls and foundations.

acquire dry rot and decay more or less in from 3 to 4 years. Wood laid on concrete direct will not burn except through the strongest provocation; it will smoulder and become

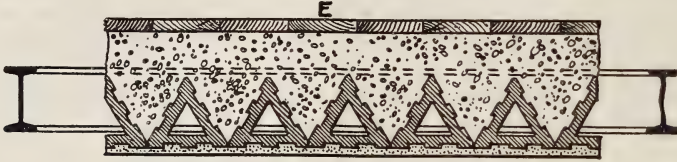


FIG. 15.—HOMAN'S FLOOR.

5. The plastered ceilings should, if possible, be of a character that will not fall or come away as the immediate result of a fire beneath.

The properties aimed at in fire-resisting floors of domestic buildings should be, I submit, as follows:—1, resistance to fire; 2, non-conductivity of sound; 3, lightness compatible with safety; 4, economy of space; and 5, economy of cost.

I have endeavoured to carry out these principles in the floor shown, Fig. 16, but

charred. Small wood joists laid on the concrete and floor boards fixed thereto in the usual way, will burn rapidly.

I think it is worthy of being more generally known that cement used for making concrete parts with as much water as is unnecessary for hydration, and clear water can always be seen dripping from concrete newly laid on temporary centreing or wood platform formed to uphold it.

This is often supposed to be a case of too

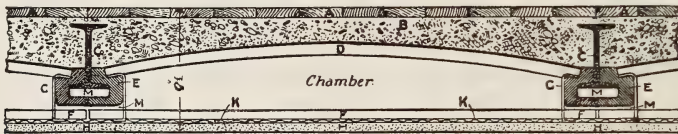


FIG. 16.—POTTER'S FLOOR.

although highly successful on a small scale, like everyone else's patents, I am unfortunately unable to say what the result would be in a genuine big fire. The bottom flanges are encased with burnt-clay shields, E, an air space M, intervening, and a metallic lath suspended ceiling is fixed to the shields by iron hangers, G, and lathing bars, F; permanent iron centres, D, are used for forming the floor, and the bottom flanges of joists have a double air space protection; A is wood surface; B, concrete; H, metal lathing.

The best covering for a concrete floor is wood in narrow widths, nailed direct on the concrete. Obviously the floor must be first made quite straight, and the materials of a consistency that will enable nails driven therein to hold as well as if driven into wood. It has been said that the wood will rot, but I have made floors in this way for 16 years and found no decay yet, and for some reasons they are preferable to wood block floors and cost less. Dovetailed strips of wood embedded in concrete for nailing boards thereto I found

much water having been used in mixing, but it is not so, unless it is coloured with cement, in which case it is evidence of the latter having been carried through the concrete owing to the use of an excess of water, and the floor is obviously weakened therefrom. Men used to forming concrete floors acquire practical knowledge as to these and other little details of construction which the casual labourer cares nothing about.

As a matter of fact, concrete for any purpose is assumed to be such a commonplace thing that it is difficult to evoke any interest in connection therewith, so far as building matters are concerned. But the large fires which have taken place will, it is hoped, be the means of inducing the London County Council or the Government, or some other independent authority, to make a series of independent tests of various kinds of fireproof floors, partitions, beam encasements, &c., as done in several other countries, that architects and the public in general may be put in possession of some reliable data relative to so

called fireproof buildings, and if a building was set apart for specimens and exhibits of fireproof floors, partitions, cements, inventions, and products relating to fireproofing generally, architects and others would be able to see and judge for themselves as to what would be likely to fulfil their requirements instead of having to rely entirely upon pamphlets, advertisements, or circulars.

I regret that the time allowed me only permits a skimming of the subject, and that I have perforce had to leave much unsaid. I thank you for the great attention which has been accorded me.

DISCUSSION.

MR. H. H. COLLINS said it was evident from the paper that Mr. Potter was a master of his subject; but nevertheless there were some points on which he was obliged to differ from him. Statistics with regard to fires were very fallacious, and from something like forty years' experience his conclusion was that what most required to be guarded against were fires in large commercial buildings, theatres, &c., the risk of private houses being very small, as was proved by the premiums charged by insurance companies. For commercial buildings the rate ranged from 5s. up to 21s. per cent., while in private houses it was from 1s. 6d. to 2s. 6d. There were many circumstances to be taken into account before forming an opinion as to the mortality from fire in private houses, and he could not place so much reliance on the statistics as Mr. Potter appeared to do. Before the London County Council prepared the Metropolitan Building Act they took the advice of the district surveyors, of the Institute of British Architects, the Institute of Surveyors, and the Institute of Builders, and many discussions took place before the Bill became law, and it contained many useful provisions which had not been alluded to. For instance, as to the erection of chimneys, the setting of stoves and ranges, carrying party walls through the roof, the cubical contents of warehouses, and a very important point which arose out of a bad fire in the Edgware-road, where a draper took a number of small houses and removed the party walls and so forth; under the Act that could not be done now. There was also a further limitation on the height of buildings. The only mistake was in allowing, to meet the aesthetic views of some people, the woodwork of windows to come out flush with the walls. Architects were fully aware of the advantages of fire-resisting construction; it was impossible to make buildings absolutely fireproof, but the great difficulty was the expense. All patentees told you what the extra cost would be theoretically, but in practice it always came to about three times as much. They put forth pamphlets and circulars and inundated

you with samples, and each one told you his own system was perfect, but, unfortunately, gave you no data to warrant such an assertion. Each one said his was much better than anybody else's, and in the result the architect had to judge for himself. He had no doubt this paper was written, in great measure, in consequence of the recent calamitous fire in the City; but a great many observations were made in connection with that which were not borne out by facts. One gentleman said the extra cost of fire-resisting construction was 50 per cent., another put it at 25 per cent., and Mr. Potter said it was about 7½; but then he was a manufacturer. He (Mr. Collins) should say 30 per cent. would be nearer the truth, and taking his own example of a house costing £2,000, that would add £620, and add £30 to the rental, bringing it from £150 to £180, and it must be remembered that the rates and taxes would be increased in proportion. The result would be that the house would not let, or would be the last one let in the locality. The cost, therefore, was prohibitive, except in the case of a man with plenty of money building for his own occupation; it would never do for a speculator, and, therefore, it would be many years before such a system could be introduced for ordinary dwelling-houses. The only way to press the matter would be for insurance companies to decline to insure ordinary buildings except at prohibitive rates. The law would not do it, and indeed he should be sorry to see the House of Commons engaged in a debate of such a kind; he thought there was too much legislation already. Again, if they followed the suggestions of the paper, and do away with all wainscoting, dados, friezes, and architraves, the house would be more like a barn. There were other points to be remembered in connection with resistance to fire, which had not been touched upon: it was not a question simply of the floors and roofs. As Sir Eyre Shaw had told them the foundation was of primary importance, for if it were defective settlements and fissures would occur, which often caused more danger if a fire took place than the materials used, as the smoke and flame passed through these interstices and caused the fire to spread. The brickwork also was important, and especially the mortar used in connection with it: and he was glad to see that the London County Council insisted on their district surveyors looking strictly after this matter, as could be seen from the numerous summonses for using improper mortar. The floors which had been described were very heavy, and, unless the weights were properly considered, threw a great strain on the walls and foundations. They were also generally deep, and, therefore, involved either reducing the height of the rooms or making the building higher, with additional expense in the walls, staircases, and other matters. One question which Sir Eyre Shaw laid special stress upon, and which the London County Council specially considered, was the cubical contents of buildings. One gentleman, who gave evidence at the recent

inquest, said he knew a building which was of 480,000 cubic feet, but under the Building Act no building could exceed 250,000 without special permission, the utmost limit being 400,000, and then a special application must be made, and it must pass the ordeal of the London Fire Brigade. The risk of fire was in direct proportion to the cubical contents. The accessibility of a building was also of great importance, and the results of streets being narrow and tortuous was well exemplified in the last great fire. Then again the height of party walls must be considered. There was a large fire in the Tower Hill district, where there were three large warehouses together, larger than would now be allowed to be built, but, owing to the walls being carried up 7 or 8 feet through the roof, one warehouse only was burned, and the others remained absolutely intact. Mr. Potter had spoken against the use of wood, but on that point he should like to read a portion of a letter which Sir Eyre Shaw wrote to the *Times*, which his own experience entirely corroborated; he had written reports for insurance claims on Memel timber, which formed the beams supporting the floors of the building, when all the iron and stone work lay in the *débris* around him. Sir Eyre Shaw, speaking of the great fire at the Pantechnicon in Motcombe-street, said the structure was of brick, with wooden floors, supported on wooden beams, which in their turn were carried on wooden storey posts about 12 inches thick, and although much damage was done, not one portion of the heavy woodwork was destroyed. Further on, after describing the experiment he made with these posts, exposing them to a fierce fire for $2\frac{1}{2}$ hours, he said that within a few minutes after withdrawing them from the flames, they ceased to burn, and on sawing them and splitting them with steel wedges he found the interior still fresh and sound, and they were probably still capable of supporting the whole weight they were originally designed to carry. The lesson he drew was that a massive storey post of the most inflammable wood—in that case pitch pine—was absolutely proof against any heat which could be applied to it, and would not of itself burn at all, but required a considerable supply of highly inflammable substances to keep it burning, and after being exposed for seven hours to flames of great intensity, it was not injured to a greater depth than 2 inches from the outer surface. A large number of experiments had been made in Berlin as to the best method of construction—the results of which were published in the *Builder*—and he believed they showed that the best, and indeed the only, kind of material to resist flame was something like Homan's or Fawcett's; there were several much on the same lines. With regard to flat roofs, and their use as playgrounds and for drying linen, his experience was that the soot and dirt would render them quite unfit for the latter purpose. Mr. Potter spoke of a conservatory in the City where grapes were growing; he hoped it was not in his district, or he should try to have it removed as

a dangerous structure. There was no difficulty in making a sloping roof fire-resisting, using metallic lathing well plastered, for, as Sir Eyre Shaw said before, an inch of plaster would protect any iron; the only difficulty was to make the plaster adhere and keep in position; but that must be secured by the use of expanding metal. In Bankes's material thin uprights were put up from floor to ceiling and tied together, and the interstices filled in with plaster of Paris or concrete. That had been used at the "Three Nuns" Hotel, Aldgate, and it proved to be a bad conductor of sound. You could not hear what was said in the adjoining room, only a dull sound, however loud the words were shouted. The conduction of sound was a great nuisance which attached to some fire-resisting materials, especially in flats. In conclusion, he felt that they were much indebted to Mr. Potter for this paper, but he feared the great and insurmountable obstacle to the general adoption of his ideas would be the expense.

Mr. E. O. SACHS said he highly appreciated this paper, and particularly the fair and impartial manner in which the systems of other manufacturers had been dealt with. The paper applied chiefly to domestic buildings, in which fires were most numerous, and the loss of life greatest, but the figures required a little analysis. It was said that 100 lives per annum were lost, but probably the Fire Brigade saved as many more, and they heard that an improved system was being arranged, which would do immense service in minimising the loss of life. He did not think the great expense of fire-resisting construction arose so much in ordinary dwellings, though it was doubtful if the extra expense required would be undertaken. But the paper was very instructive with reference to buildings of the warehouse class, and the Cripplegate fire was an object-lesson of what should not be done, and it had been well pointed out that the whole question was one for tests and experiments, and it would be a great boon to architects if a thorough set of tests could be made. There was a Fire Prevention Committee formed, of which he was a member, and attempts were being made to organise such experiments, and he was glad to say they had received considerable support from the fire-proofing trade, each one of whom felt sure that his system was the best in the world, and would come out of the test triumphant. Professor Aitchison said he hoped the Government would take up the question, but his own opinion was that the Government had quite enough on its hands already, and that a matter of this kind might very well be left to private initiative. However fire-resisting a floor might be, it was too often forgotten that it was supported by something, and that something might be of a dangerous character. The old floor of solid concrete was going out, and anyone who had seen the fires which had occurred under such floors, and the ravages caused by their expansion and con-

traction, must hope that they would soon be done away with entirely.

Mr. W. ECKSTEIN said it appeared from the diagrams exhibited that the floors they illustrated were principally for warehouses and such purposes, which was one of the most important necessities. But there were many other points which might be taken up by the County Council, or some body which had the power of regulating these things. For instance, match-lining for ceilings and partitions should be prohibited. Partitions should be made of quartering, hollow and filled in solid with concrete, which was a very common practice in France; this would also do well for domestic purposes. The question of protection from fire had been very carefully considered in the New York Building Act, under which only stone—which was not a good material—steel, concrete, and hollow ware of terra cotta were allowed for a fireproof building. The last-mentioned was in almost universal use. One continuous floor was put in from back to front, and on it were put up the partitions made of expanded metal, or metal laths of some kind, which were used enormously; where we used a foot they used a square mile. These were only about $1\frac{1}{4}$ inch thick, built solid, which effected a great saving in floor space. In New York, if you rented an office, you paid so much per square foot. He had put up partitions of this kind in Wimbledon College, and was informed by the teachers—and had tested the matter himself—that they were practically soundproof. The question was one of enormous importance, and he hoped the County Council would nominate a committee, with the assistance of the Institute of British Architects, and perhaps of the fire insurance companies and the Fire Brigade, who would really settle once for all which was the best system of fireproof construction for the City of London. It would be a small matter to spend a few thousand pounds on such an object in making a series of really practical experiments. Two long walls might be put up 20 feet apart, and each manufacturer or patentee might have, say, 10 feet allotted him on which to put a floor, with columns and certain protections placed between the various systems, and then let the Fire Brigade roast the whole lot for a certain time and then quench them with water, and thus get some practical proof of their merits. If something of that kind could be done, money would be well spent upon it.

Mr. LASCELLES SCOTT regretted the omission from the paper of one word—convection—which gave the key to a great deal of the effects of fire, and, therefore, a notion of one of the first principles to be carried out in the endeavour to prevent it. The forces brought to bear in extinguishing a fire had also to be considered; water taking the first place, and so-called chemical fire-engines a bad second. If it were the rule that in the case of a large building no area above a certain size should be left open in case of fire, and it could be rendered impossible for any

roof to be burned out in a short space of time as at present, it would give water a chance of extinguishing the red hot surfaces, and chemical vapours a chance of extinguishing the flames. One point which bore upon this, was the flat roofs suggested many years ago by Dr. Richardson and himself. Three inches of water on the top of a house would give the means of stopping convection, and would give ample time for the fire-engines to arrive. It would take a long time to burn through three or four inches of water, and there would be no difficulty in keeping the top of the house sufficiently cool, so that the vapours could not ascend until means were at hand for extinguishing the fire beneath. If a series of experiments were carried out as had been suggested, he hoped this point would not be neglected. In New York they were so well insured that fires were constantly occurring, and did not even collect a crowd. With regard to legislation, he would only suggest that no building should be allowed to have a furnace-like ventilating shaft or lift cylinder in it, unless there were means of automatically shutting it off in a few seconds.

Mr. ROBBINS said he was practically connected with concrete work, and many years ago, when experimenting at Cubitt's in order to get bricks of certain colours, he tried a few experiments on his own account, and incorporated sawdust with concrete, terra-cotta, and similar materials. He found it answered admirably, the bricks being very light; and in 1869 he took out a patent, which he claimed was the origin of all the tubular systems for building purposes. Partitions might be built up in this way, using straw or reeds in place of sawdust, embedded in concrete; being non-conducting, if the bottom partition ignited the fire would not spread upwards.

Mr. S. GAMBLE said if architects would insist on some of the so-called fireproof buildings being better tied together or secured partly by concrete arches, they might possibly, in the course of the next fifty years, get firemen to have more confidence in such structures. There were some buildings termed fireproof, which when alight caused the greatest anxiety to those in charge to keep the men away from for fear they should collapse, which they invariably did sooner or later. He remembered a case of a large stone landing on the staircase of a large house not far from the British Museum, where there was a comparatively small fire, but a little water was thrown on that landing, and the whole thing collapsed and nearly caused the death of three persons. He would rather go up a wooden staircase which was half or three-quarters burnt through, than up a stone or concrete one. Again, if people would only take the precaution to close doors after them, and especially to close them when there was a fire, many lives would be saved. An ordinary four-panelled door would stand what many people would call a tremendous heat for a considerable time before giving way. If springs

of doors could be so arranged that all doors would close automatically, a great deal of damage would be saved. With regard to flat roofs, and so on, if you had a fire in a building, and a tremendous heat, it had to get out somewhere, and if the roof were of concrete it could not go that way, but would get out at the windows, back and front, and might fire the buildings on the opposite side of the road. In some cases it was even advisable to let the roof burn, and a party wall of 2 or 3 feet in height was in most cases sufficient to deflect the current of air upwards.

The CHAIRMAN, in proposing a vote of thanks to Mr. Potter, said the paper was not written in consequence of the Cripplegate fire, and was prepared entirely without reference to the catastrophe. The discussion had somewhat wandered from the actual subject, which was domestic dwellings, but he had not thought it desirable to interfere, because just now all matters concerned with fires were of great public importance. The discussion had turned largely on the mode in which large warehouses and public buildings should be constructed, and happily those were more or less under the control of the local authorities, and as Mr. Collins had pointed out certain regulations as to area, height, &c., had been laid down, which were of the greatest importance. In any case, they were greatly indebted to Mr. Potter for his excellent paper, though, no doubt, what he had chiefly in mind was the prevention of running up jerry buildings in suburban localities, in such a way that they would burn like tinder, if once a fire started as Mr. Gamble could probably testify.

The vote of thanks was carried unanimously.

Mr. POTTER, in reply, said many of the points mentioned by Mr. Collins did not really arise on the paper, which was intended to refer only to domestic buildings. With regard to the depth of the floors, they need not exceed 10 inches, including the wooden ceiling, and you could not have less with wood. If the suspended ceiling were used, air could be introduced between the ceiling and the roof; and in case of fire, the heated air could escape through apertures in the walls. He believed all those little difficulties could be got over.

Miscellaneous.

CARPET MAKING IN JAPAN.

A Japanese industry which employs a large number of hands, and chiefly children, is carpet making. In Japan the carpet is a modern luxury. Before the days of foreign trade, cotton carpets with a long pile an inch in length, in imitation of the Chinese article, were made in small quantities, and when, after the signing of the foreign treaties, European goods began to be introduced, carpets greatly took the Japanese fancy. Mr. Byron Brenan, in a recent report to the

Foreign-office, says that the carpet makers of Sakai, the chief seat of the industry, situated about six miles from Osaka, took hints from the foreign articles, and in course of time improved so much upon their earlier processes, that already in 1878 cotton and jute carpets began to be exported to Europe and America. The trade has now grown to large proportions, and it affords one instance of the Japanese being able to beat those from whom they learnt. Carpet making affords a striking example of the successful competition between cheap labour and machinery. At Sakai there is no large factory, the hand-loom is distributed all over the town, and the carpet dealers supply the material and pay the workers by the piece. In each house there may be three or four looms, ranging from 3 to 24 feet wide. To each loom there are from two to four children, with a grown-up person superintending the work. With incredible speed the children, some of them as young as seven, pass the yarn in and out of the warp and snip off the right length with a pair of spring clippers. They are all kneeling at their work on a plank laid at the foot of a loom, and they slide backwards and forwards along their allotted share of the design. As their little fingers pass the yarn in and out of the cotton threads, these small children sing a sort of nursery rhyme which helps them to remember the pattern, and at intervals the woman in charge leads off a new verse, which the children at once take up, and simultaneously effect the change suggested by the new music and the words. They work, or at least are at their work, for twelve hours a day, and their wages come to about one penny a day. The price of a rug made of cotton or hemp depends upon the number of threads in warp and woof; about 250 threads to a yard is the average quality. Woollen carpets are being manufactured, but in price they seem far to exceed similar carpets made in North China without a corresponding improvement in quality. Australian wool is used, which of course is much dearer than the Mongolian wool. Small silk carpets are also being made, but the demand for these is limited; they cost as much as £1 sterling per square foot; for a carpet of any given dimension 90 times the labour is required as in the case of a hempen carpet. Three hands will make an ordinary hemp or wool rug, 3 by 6 ft., in one day, and it would take the same workers three months to make the silk carpet. The number of carpet-weaving establishments in the district of Osaka is nearly 2,000, producing 3,000,000 square yards of carpets in the year, and in them are employed 5,000 male and 13,000 female workers.

Correspondence.

THE PURIFICATION OF SEWAGE BY BACTERIA.

I am afraid the readers of this *Journal* will be getting rather tired of the discussion on the above

subject; nevertheless, I would ask to be allowed space for a few further remarks.

In the first place, I must thank Mr. Roechling for drawing my attention to the experiments by Dr. A. Mueller, made in 1869, but published only in 1873, which, I am sorry to say, I had not previously heard of; it is a pity that this paper was not published in a journal of wider circulation. From the extracts given, it is, however, clear that Dr. Mueller had fairly grasped the fact that the destruction of the organic matters in sewage was due to the action of organisms. He seems, however, to have considered it to be mainly a process of hydrolysis, and he does not appear to have then contemplated its practical application to the purification of sewage.

Mr. Kingzett's extracts from publications of his own are mainly generalities with no direct bearing on the purification of sewage.

I quite agree with Dr. Rideal that in many cases the process of purification of sewage by bacteria takes place in two stages, but he has not, I think, proved that such is always the case. Does sewage which is destroyed by admixture with a large volume of aerated water, or by filtration through an efficient oxidizing bacteria filter, pass through these two stages? If so, how is this shown? So far it is, however, evident that sewage cannot be finally disposed of by hydrolytic processes alone, and the practical problem is: How best to divide the work if division is necessary between the two agencies in question, so as to obtain the desired result in the cheapest and most perfect manner. One word more. Whoever may lay claim to having started the idea of the purification of sewage by bacteria, it is but fair to say that the question assumed great practical importance only when Mr. Dibdin began his experiments on a large scale at Barking and Sutton in 1891 and 1892 respectively.

A. DUPRÉ.

January 25, 1898.

General Notes.

ITALIAN WINE PRODUCTION.—According to statistics furnished by the Italian provincial authorities, the wine harvest of Italy, in 1897, is estimated at 586,487,000 gallons, as compared with 624,726,000 gallons in 1896; a falling off of 38,239,000 gallons. It should, however, be borne in mind that the figures for 1897 are approximate only, and liable to modification. The following shows the amount of wine produced last year in the various districts of Italy, compared with those for 1896:—

	Gallons. 1897.	Gallons. 1896.
Piedmont ..	72,201,800	57,636,700
Lombardy ..	20,941,800	21,986,492
Venetia ..	18,062,000	21,886,040
Liguria ..	7,092,800	5,326,200

	Gallons. 1897.	Gallons. 1896.
Marches and		
Umbria ..	62,946,400	42,527,300
Emilie ..	29,847,400	43,710,920
Tuscany ..	50,608,800	62,599,460
Latium ..	30,804,400	24,643,740
Southern		
Adriatic ..	127,039,000	144,991,000
Southern Medi-		
terranean ..	72,564,800	82,872,900
Sicily ..	77,981,200	103,141,280
Sardinia ..	16,396,600	13,404,160

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock:—

FEBRUARY 2.—“The Cinematograph.” By JULES FUERST. CAPTAIN W. DE W. ABNEY, C.B., F.R.S., will preside.

FEBRUARY 9.—“Compensation to Workmen.” By A. D. PROVAND, M.P.

FEBRUARY 16.—“The Protection of Industrial Property.” By J. F. ISELIN, M.A., LL.M.

FEBRUARY 23.—“Children's Sight.” By R. BRUDENELL CARTER, F.R.C.S.

MARCH 2.—“Kites: their Theory and Practice.” By Captain B. F. S. BADEN-POWELL.

MARCH 9.—“Linde's Method of Producing Extreme Cold and Liquefying Air.” By Professor J. A. EWING, F.R.S.

MARCH 16.—“The Recent History of Paper-making.” By CLAYTON BEADLE.

MARCH 23.—“The Preparation of Meat Extracts.” By C. R. VALENTINE.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock:—

FEBRUARY 17.—“The Plague in Bombay.” By HERBERT MILLS BIRDWOOD, C.S.I., M.A., LL.D. (late Governor's Council, Bombay). The Right Hon. EARL SPENCER, K.G., will preside.

MARCH 10.—“India and Sir Henry Maine.” By CHARLES LEWIS TUPPER, C.S.I. The Right Hon. Sir MOUNTSTUART ELPHINSTONE GRANT DUFF will preside.

MARCH 31.—“The Earthquake in Assam.” By HENRY LUTTMAN-JOHNSON, I.C.S.

APRIL 21.—“The Rise, Progress, and Present Position of the Native Press of Western India.” By R. P. KARKARIA (of Bombay).

APRIL 28.—“India and Currency.” By Sir EDWARD SASSOON, Bart.

MAY 19.—“Chartered Companies and Colonisation.” By Sir ALFRED COMYNS LYALL, G.C.I.E., K.C.B., D.C.L. (Member of the Council of India).

The meetings of February 17, and March 31, will be held at the Imperial Institute;

those of March 10, April 21, April 28, and May 19 at the Society of Arts.

FOREIGN AND COLONIAL SECTION.

Tuesday Afternoons, at 4.30 o'clock :—

FEBRUARY 15.—“The Goldfields of Klondyke and British Columbia.” By W. HAMILTON MERRITT. Sir CHARLES MALCOLM KENNEDY, K.C.M.G., C.B., will preside.

MARCH 15.—“The African : what he is, and what he is capable of becoming.” By the Rev. GODFREY DALE (Universities Mission to Central Africa).

APRIL 5.—“The Sugar Industry in the West Indies.” By T. R. TUFNELL.

APPLIED ART SECTION.

Tuesday Evenings, at Eight o'clock :—

FEBRUARY 22.—“The Regalia of England.” By CYRIL DAVENPORT. Sir GEORGE BIRDWOOD, K.C.I.E., C.S.I., will preside.

MARCH 8.—“The Making of a Stained Glass Window.” By LEWIS FOREMAN DAY.

MARCH 29.—“English Art in Illuminated MSS.” By Sir EDWARD MAUNDE THOMPSON, K.C.B.

APRIL 26.—“The Importance of Craftmanship.” By Sir WILLIAM BLAKE RICHMOND, R.A., K.C.B.

MAY 10.—“The Art of William Morris.” By F. S. ELLIS.

MAY 17.—“Practical Points in Italian Majolica Painting.” By WILLIAM BURTON, F.C.S.

CANTOR LECTURES.

Monday Evenings, at Eight o'clock :—

CYRIL DAVENPORT, “Decorative Book-binding.” Three Lectures.

LECTURE II.—JANUARY 31.—Decorative book-binding in Continental Europe, chiefly Italy, France, and Germany, from the 16th to the 18th centuries inclusive, with some notice of Oriental bindings.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JAN. 31... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Cyril Davenport, “Decorative Bookbinding.” (Lecture II.)

Farmers' Club, Salisbury-square Hotel, Fleet-street, E.C. 4 p.m. Mr. H. Le Roy Lewis, “The Supplementary Report of the Royal Commission on Agriculture.”

Imperial Institute, South Kensington, 8½ p.m. Mr. Harry de Witt, “Klondike.”

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Mr. H. S. H. Cavendish, “Through Somaliland to Lake Rudolf.”

Actuaries, Staples-inn-hall, Holborn, 7 p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. G. B. Howes, “The Position of the Mammalia in the Animal Series.”

TUESDAY, FEB. 1... Royal Institution, Albemarle-street, W., 3 p.m. Professor E. Ray Lankester, “The Simplest Living Things.” (Lecture III.)

Central Chamber of Agriculture (at the House of the SOCIETY OF ARTS), 11 a.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Mr W. L. Strange's Paper

“Reservoirs with High Earthen Dams in Western India.”

Biblical Archaeology, 37, Great Russell-street, W.C., 8 p.m.

Zoological, 3, Hanover-square, W., 8½ p.m. 1. Mr. G. A. Boulenger, “A Collection of Fishes from the Rio Jurua, Brazil.” 2. Mr. F. E. Beddard, “The Anatomy of an Australian Cuckoo, *Scythrops nove-hollandie*.” 3. Dr. A. G. Butler, “A Collection of Lepidoptera made by Mr. F. V. Kirby chiefly in Portuguese East Africa.”

Colonial Inst., Northumberland-avenue, S.W., 4½ p.m. Mr. E. R. Calthrop, “Light Railways.”

WEDNESDAY, FEB. 2... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Jules Fuerst, “The Cinematograph.”

Geological, Burlington-house, W., 8 p.m.

Archaeological Association, 32, Sackville-street, W., 8 p.m.

Obstetrical, 20, Hanover-square, W., 8 p.m.

THURSDAY, FEB. 3... Royal, Burlington-house, W., 4½ p.m. Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. G. C. Crick, “The Muscular Attachment of the Animal to its Shell in some fossil Cephalopoda (Ammonoidea).” 2. Mr. W. C. Worsdell, “The Comparative Anatomy of certain Genera of Cycadaceae.”

Chemical, Burlington-house, W., 8 p.m. 1. Mr. E. Sonstadt, “Dissociation of Potassium

Platinichloride in Dilute Solution, and the Production of Platinum Monochloride.” 2. Drs

Percy Frankland and Thomas Stewart Patterson “Effect of the Mono-, Di-, and Tri-chloracetyl-

Groups on the Rotatory of Methylic and Ethylic Glycerates and Tartrates.” 3. Drs. Percy

Frankland and Andrew Turnbull, “The Rotation of Ethylic and Methylic Di-monochloroacetyl-

tartrates.” 4. Mr. H. J. H. Fenton, “The Volumetric Estimation of Sodium.”

London Institution, Finsbury-circus, E.C., 6 p.m. Mr. R. Kearton, “Haunts and Habits of British

Birds.”

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Dewar, “The Halogen Group of Elements.”

(Lecture II.)

Camera Club, Charing-cross-road, W.C., 8½ p.m. Mr. P. W. Ames, “Physiology of Thought and

Memory.”

FRIDAY, FEB. 4... Royal Institution, Albemarle-street, 8 p.m. Weekly Meeting. 9 p.m. Mr. A. Campbell Swinton, “Some New Studies in Cathode and Röntgen

Radiations.”

Geologists' Association, University College, W.C., 7½ p.m. Annual Meeting. President's Address on “Palaeolithic Man.”

Junior Engineers, Westminster Palace Hotel, S.W., 8 p.m. Mr. L. H. Walter, “Electromagnetic

Brakes and their Capabilities.”

Quekett Microscopical Club, 20, Hanover-square, W.C., 8 p.m.

SATURDAY, FEB. 5... Royal Institution, Albemarle-street, W., 3 p.m. Prof. Patrick Geddes, “Cyprus.”

(Lecture III.)

Journal of the Society of Arts.

No. 2,359. VOL. XLVI.

FRIDAY, FEBRUARY 4, 1898.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****CANTOR LECTURES.**

On Monday evening, 31st inst., Mr. CYRIL DAVENPORT delivered the second lecture of his course on "Decorative Bookbinding," which was illustrated by a series of lantern slides of French, Italian, Spanish, and Portuguese Bookbindings.

The lectures will be published in the *Journal* during the summer recess.

EXHIBITION OF BOOKBINDINGS.

An Exhibition of Foreign and English Ornamental Bindings is now open in the Reading Room of the Society of Arts, and will remain open daily until Monday evening, February 7th. Hours: 10 to 5 p.m., and on the evening of Monday from 6 to 9.

Members can admit their friends by the use of the usual meeting tickets supplied to members. There will be no restriction as to the number of tickets.

A Catalogue of the Collection has been printed, and can be obtained on application.

Non-members of the Society can obtain cards of admission on application to the Secretary, Society of Arts, John-street, Adelphi, W.C.

Proceedings of the Society.**FOREIGN & COLONIAL SECTION.**

Tuesday, January 18, 1898; Maj.-Gen. SIR OWEN TUDOR BURNE, G.C.S.I., K.C.I.E., Chairman of the Council, in the chair.

The paper read was—

MY RECENT JOURNEY FROM THE NILE TO SUAKIM.

BY FREDERIC VILLIERS.

THE ADVANCE TO KHARTOUM.

The recent campaign in the Sudan was a bloodless one to the correspondents with the expedition, or, rather, on the tail of the advance. Yet I think, in spite of this little drawback, there is enough in the vicissitudes of my colleagues and myself during the recent advance of the Egyptian troops up the Nile to warrant me addressing you this afternoon. Especially as towards the end of the campaign the Sirdar, or Commander-in-Chief of the Egyptian Army, Sir Herbert Kitchener, became more sympathetic with our endeavours to get good copy for our journals, and allowed us to return home by the old trade route of the Eastern Sudan, over which no European had passed since the revolt of the Eastern tribes in 1883. Unfortunately, the period for campaigning in the Sudan is in the hottest months in the year, on the rising of the Nile at the end of July, when the cataracts begin to be practicable for navigation. At the same time, in spite of the heat, it is the healthiest period, for the water, in its brown, muddy, pea soup state, is wholesomer to drink, and the banks of the river which, when exposed at low Nile give off unhealthy exhalations, are protected from spreading fever germs by the flood. To show you how much the people of Egypt depend for their very existence on this extraordinary river, the average difference between high and low Nile, giving favourable results, is 26 feet. Twenty-eight feet would cause serious damage by inundation, and the Nile as low as 20 feet would create a famine. The flood of the river depends entirely on the equatorial rains which cause the Upper White Nile to rise in April and the Blue Nile early in June. The muddy Atbara, joining her two sisters about the same time sends the flood down to Lower Egypt towards the end of August at the rate of 100 miles a day. The Blue Nile in the middle of September falls rapidly away, while the Atbara leaves the trio in October. The White Nile is then left by herself to recede slowly and steadily from a current of four knots an hour to a sluggish, and in many parts, an unwholesome stream. Flies and mosquitos increase, and fever is rife.

I arrived in Cairo on a sweltering day in July, and found four colleagues, who had been

waiting for a week the Sirdar's permission to proceed to the front, still waiting. Luckily, the day after my arrival a telegram came from headquarters, saying "that we might proceed as far as Assouan and there await further orders." This, anyhow, was a move in the right direction, so we at once started. It was rather a bustle for me to get things ready, for Sunday blocked the way, and little could be done, even on that day, in Cairo. I procured a servant, a horse, and two cases of stores, for the cry was "nothing to be had up country in the shape of food; hardly sufficient sustenance to keep the flies alive." My colleagues, who had the start of me, were able to procure many luxuries—a case of cloudy ammonia for their toilet, and one of chartreuse, komel, and benedictine to make their after dinner coffee palatable, and some plum pudding, if Christmas should still find them on the war-path, were a few of the many items that made up the *trousseau* of these up-to-date war correspondents, though at least one of them had been wedded to the life for many years. Unfortunately, I had no time to procure these luxuries, and I had to proceed ammonialess and puddingless to the seat of war. My comrades were quite right; why not do yourself well if you can? One of them even went in for the luxury of having three shooting irons, two revolvers, and a double-barrel slug-pistol, so that when either of the weapons got hot while he was holding Baggara horsemen at bay, there was always one cooling, ready to hand. He also, which I believe is a phenomenal record with any campaigner, took with him thirteen pairs of riding breeches, a half dozen razors, and an ice machine. Even our Commander-in-Chief, when campaigning, denies himself more than two shirts, and never travels with ice machines. But the thirteen pair impressed me considerably. Why thirteen, more than fifteen, or any other number? I came to the conclusion that my colleague must certainly be a member of that mystic body the "Thirteen Club," and as he had to bring in the odd number somewhere to keep the club fresh in his memory, he occasionally sat upon it.

I found, after all, there was some wisdom in his eccentricity, for, when riding the camel, mounted on the rough saddle of the country, I often wished that I had my friend's forethought, and I should have been glad to have supplemented mine with his odd number. No doubt my colleague's idea in having such a variety of nether garments was to use them respectively, on a similar principle to the revolvers

when he rode in hot haste with his vivid account of the latest battle to the telegraph office.

But, unfortunately, this recent campaign did not, after all, necessitate these elaborate preparations, for there were no dervishes for us to shoot at or descriptions of bloody battles to be telegraphed. At all events, the cloudy ammonia and the thirteen breeches, with the assistance of a silken sash—a different colour for each day of the week—made the brightest and smartest looking little man in camp. However, when I reflect on this new style of war correspondent, who, I forgot to mention, also carried with him two tents, a couple of beds, sundry chairs and tables, a silver-mounted dressing case, two baths, and a gross of toothpicks, and I think of the severe simplicity of the old style of campaigning when a famous correspondent who is still on the war-path, and who always sees the fighting if there be any, on one arduous campaign took with him the modest outfit of a tooth brush and a cake of carbolic soap. I joyfully feel that with the younger generation our profession is keeping pace with the luxury of the times.

FROM BERBER TO SUAKIM.

Towards the end of the campaign four colleagues—Messrs. Knight, Gwynne, Scudamore, Maud—and myself, took this opportunity of traversing a country very little known to the outside world, and a route which no European had followed for fourteen years, from Berber to Suakim. Moreover, there was a spice of adventure about it; there was an uncertainty regarding an altogether peaceful time on the way—a contingency which always appeals strongly to Englishmen of a roving and adventurous disposition. Only quite recently raids organised by the apparently irrepressible Osman Digna had been successfully carried out a few miles north and south of Berber. At the moment General Hunter, with two battalions of troops, was marching along the banks of the River Atbara to hunt for Osman and his followers, but there was much speculation as to whether five-and-twenty Dervish raiders were still this side of the river, and drawing their water from the wells on the Suakim road.

I was hardly prepared for this journey—one, probably, of twelve days—for my campaigning outfit, which I was compelled to leave on board my nigger on the Nile, had not yet arrived in Berber. Unfortunately, I could not wait for the gear, as the Sirdar insisted on our departure

at once, for the road would be certainly insecure directly General Hunter returned from covering our right flank on the Atbara. I had no clothes but what I stood up in, and I had been more or less standing up in them without change for the last two weeks.

Our caravan of nineteen camels, with two young ones, quite babies, following their mothers, and a couple of donkeys, about seven in the evening of the 30th of October quitted the mud-baked town of Berber, sleeping in the light of a new moon, and silently moved across the desert towards the Eastern Star. Next morning at the Morabeh Well, six miles from Berber, our camels having filled themselves up with water, and our numerous girbas, or water-skins, being charged with the precious liquid—till they looked as if they were about to burst—our loads were packed, and we started on a journey of fifty-two miles before the next water could be reached.

We made quite a formidable show trailing over the desert. Probably it would have been more impressive if our two donkeys had restrained their ambition, and kept in the rear instead of leading the van. But animals mostly have their own way in these parts, and asses are no exception to this rule. The two baby camels commenced "grouching" with their elders directly we halted or made a fresh advance; they probably had an inkling of what was in store for them. After all, the world must seem a hard and unsympathetic place when, having only known it for two or three weeks, you are compelled to make a journey of 240 miles to keep up with your commissariat. One of these babies was only in its eighteenth day. In spite of its tender youth the little beast trotted by the side of its mother, refreshing itself, whenever we came to a halt, with a pull from her teats, and, to the astonishment of all, arrived in Suakim safe and sound after twelve days' marching.

To the uninitiated regarding the "grouching" of camels, I should explain that it is a peculiar noise which comes from their long funnel necks early or late, and for what reason it is difficult to tell. Sometimes the sound is not unlike the bray of an ass, occasionally it reaches the dignity of the roar of a lion, with the bleating of a goat thrown in, then as quickly changes to the solemnity of a church organ. It is altogether so strange a sound that nothing but a phonograph could convey any adequate idea of it. It is a thing to be heard. No pen can properly describe it. After a long march, and when you are preparing to relieve the brute of his

load, he begins to grouse. When he is about to start in the morning he grouses. If you hit him he grouses; if you pat his neck gently he grouses; if you offer him something to eat he grouses; and if you twist his tail he makes the same extraordinary noise. The camel evidently has not a large vocabulary, and he is compelled to express all his various sensations in this simple manner.

The first part of our journey was monotonous enough, miles and miles of weary sandy plains, with alternate stretches of agabas or stony deserts, scored with shallow depressions, where torrential rains had recently soaked into the sand, leaving a glassy, clay-like surface, which had flaked or cracked into huge fissures under the heat of the fierce sun. And at every few hundred yards we came to patches of coarse camel grass, which had evidently cropped up on the coming of the rain, and, by its present aspect, seemed to feel very sorry that it had been induced to put in an appearance, for its sustenance was now fast passing into vapour, and its green young life was rapidly dying out as the sun scorched the tender shoots to the roots. But camels thrive on this parched-up grass, and our brutes nibbled at it whenever one slackened the head-rope.

We traversed the dreary plain, marked every few yards by the bleached bones of camels fallen by this way; the only living thing met with for two days being a snake of the cobra type trailing across our path. The evening of the second day we camped in a long wadi, or shallow valley, full of mimosa trees, where our camels were hobbled and allowed to graze. They delighted in nibbling the young branches of these prickly acacias, which carry thorns at least an inch in length, that serve excellently well for toothpicks. Yet camels seem to rejoice in browsing off these trees, and chew up their thorns without blinking. This I can partly understand, for the camel's usual diet of dry coarse grass must become rather insipid, and as we sometimes take "sauce piquante" with our cold dishes, so he tickles his palate with one inch thorns.

Climbing ridge after ridge of the dunes, we at last saw stretching before us in the moonlight the valley of Obak, an extensive wadi of mimosa and sunt trees. Our guides halted on a smooth stretch of sand, and I wondered why we were not resting by the wells. Near were three native women squatting round a dark object that looked to me, in the faint light of the moon, like a tray. I walked up to them,

thinking they might have some grain upon it for sale, but found to my surprise that it was a hole in the sand, and I realised at once that this must be a well. One of the women was manipulating a leather bucket at the end of a rope, which, after a considerable time she began hauling up to the surface. It was about half full of thick muddy water. Further on along the wadi I now noticed other groups of natives squatting on the sand, doing sentinel over the primitive wells. I never came across a more slovenly method of getting water. The mouths of the holes were not banked or protected; a rain-storm or sand-drift at any moment might have blocked them for a considerable period.

Not being able to get water for the camels was a serious matter, as our animals were not of the strongest, nor had they been recently trained for a long journey without water. This was the evening of the third day from Berber, and many of the poor brutes were showing signs of weakness. We resolved, therefore, to hurry on at once to the next well, that of Ariab; so we left the inhospitable wadi, and started at three in the morning on our next stretch of fifty-three miles.

These night marches were pleasant enough; it was only the hour or two before dawn when the heaviness of sleep troubled us; but just as we began nodding, and felt in danger of falling off our camels, the keen change in the temperature which freshens the desert in the early morning braced us up, and, fully awake, we watched for the coming of Venus. As she sailed across the heavens, she flooded the desert with a warm soft light, which in its luminosity equalled an English summer moon, and shortly seemingly following her guidance, the great fiery shield of the sun stood up from the horizon, and broad day swept over the plain.

Towards the evening we found ourselves in a boulder-strewn basin amidst rocky, sterile hills, evidently the off-shoots and spurs of the Jeb-el-Gharr, which stood out a purple serrated mass on our left, and here we saw for the first time for many a month rain clouds piling up above the rocky heights. Their tops, catching the rosy glow from the declining sun, appeared in their quaint forms like loftier mountains with their snowy summits all aglow. This was, indeed, a grateful sight to us; the camels already pricked up their ears, for the smell of moisture was in the air. We knew that the end of our waterless journey was not far off, for where those clouds were discharging their

precious burdens the valley of Ariab lay. But many a weary ridge of black rock and agaba must still be crossed before our goal was reached.

We camped at six that evening till midnight, when we started on our record march. Unfortunately at this time my filter gave out, owing to the perishable nature of the rubber tubing; the remaining water in our girbas was foul and nauseating from the strong flavour of the skins. I resolved to try and hold out without touching the thick greasy fluid, and wait till the wells of Ariab were reached. As we advanced, the signs of water became more and more apparent; the camel grass was greener down by the roots, and mimosa and sunt trees flourished at every few hundred yards. When morning came, for the first time we heard the chirruping and piping of birds. The camels increased their pace, and all became eager to reach our destination before the extreme heat of the day. But pass after pass was traversed, and valley after valley crossed, and yet the wadi of Ariab, with its cool deep wells of precious water, was still afar. It was not till past two o'clock in the afternoon that a long toilsome defile of rugged rock brought us on the edge of a steep descent, and before us lay the winding Khor of Ariab, with its mass of green fresh foliage throwing gentle shadows on the silver sand of its dry water-course. It seemed an age as we traversed that extended khor before our guide pointed to a large tree on our right, and said "Moja." We dismounted under the shadow of its branches, and found awaiting us the sheikh of the valley, who pressed our hands and greeted us in a most friendly way; but I was almost mad with thirst, and asked for the well. I was taken to a mound a few yards from our retreat, on the sides of which were two or three clay scoop-outs, all dry but one, and this held a few gallons of tepid water, from which camels had been drinking. The man took a gourd, half filled it, and offered it to me to drink. "But the well, the well!" I cried. "Oh! that's a little higher up," said he, and he led me to a wide revetted well about fifty feet deep, at the bottom of which, reflecting the sky, shone the water like a mirror. "That's the water I want," said I. The man shook his head. "You can't drink of that till your baggage camels arrive; we have no means of reaching it." I almost groaned aloud, and with the agony of the Ancient Mariner could well cry, "Water, water everywhere, but not a drop to drink." There was no help for it. I made my way back to the shadow of the tree, threw

myself on my blanket, and, racked with thirst, tried to wait patiently for the coming of the camel men. Fortunately, the sheikh of the well was inspired with hospitality, and, after a while, brought us some fresh milk in a metal wash-basin, a utensil which he evidently produced in honour of our visit. I took a long draught, and though it was associated with native ablutions, I shall always remember it with the greatest satisfaction. We camped for 24 hours in the sylvan vicinity of Ariab wells—stretched ourselves in the broad shadows of its mimosa trees, and drank of and bathed in its sweet cool waters.

This long rest improved our camels wonderfully. By-the-bye, there was much speculation between two of our party regarding the behaviour of these curious animals on arriving at the wells after their long waterless march. A general impression was that for the last few miles the camels would race for the waters, and thwart all endeavours to hold them in. My experience of the strange beast was otherwise, and subsequent events proved that I was right. When the Hamleh, as we christened our caravan, arrived, the camels quietly waited awhile after their burdens were taken from their humps. Then, as if an afterthought had struck them, they slowly approached the scoop-outs and with the most indifferent air would take a mouthful of the liquid, then stiffening their necks they would lift their heads and calmly survey the scenery around them, till their drivers would draw their attention to the fact that there was at least another draught of water in the pool. It should be remembered that these animals had just come off a continuous journey of nearly fifteen hours without a halt, and had been for three whole days without water.

We left our camping-ground as the sun began to dip behind the hills shutting in the khor. Our way now lay in a more north-easterly direction, and the sun threw the hills and valleys we were approaching into a marvellous medley of glorious colour, and more than one of us regretted that we had not brought our colour-boxes with us. Sometimes we seemed to catch a glimpse of the heather-clad Highlands of Scotland. Then a twist in the khor we were traversing suggested the rugged passes of Afghanistan. Gazelle and ariel stole among the foot hills or stood gazing at us as near as a stone's throw. One of our party, Mr. Gwynne, commenced stalking a gazelle, but, darkness setting in, the beast got away. For the rest of the journey to

Suakim, however, he had good sport, and saved us many a time from going hungry with his shooting for the pot.

About 34 miles from Ariab we came to one of the most interesting spots of the whole journey—the extensive Valley of Khokreb, wherein lay the deserted dervish dem, or stronghold. Here some followers of Osman Digna used to levy toll on all caravans and persons moving towards Suakim, or taking routes south. The dem consisted of a number of well-built tokuls, or straw huts, standing in their compounds, with stabling for horses and pounds for cattle. The whole was surrounded with a staked wall, in front of which was a zariba of prickly mimosa bush, to stop a sudden onrush of an enemy. The place was intact, but there was not a living soul within it, or in the vast valley in which it stood, that we could see. In fact, our whole journey up to the present seemed to be through a country that might have been ravished by some plague or bore some fatal curse. As the light of the moon prevailed, we came upon an extensive plain shelving upward towards steep hills. Specks of bright light stood out against the distant background, and we presently found that the moonlight was glinting on spear heads, and soon a line of camels crept towards us, and marching as escort was a small guard of Hadendowahs, with spear and shield.

We found the convoy to be a detachment of a caravan of 160 camel loads of stores sent from Suakim to Berber by that enterprising Greek, Angelo, of the former town. They had been on the road already eight days, having to move cautiously owing to rumours of dervish activity, but had arrived so far safely. We bivouacked for several hours in the Wadi of Salalat, which was quite park-like with its fine growth of sunt trees.

When we had crossed the frontier between Bisheran and Hadendowah country, we were in comparative safety regarding any molestation by the natives, for we were escorted by the son of the sheikh of one of the sub-tribes of the latter country. At all events, I must have been a sore temptation for any evil-disposed Fuzzy Wuzzy, for owing to my camel being badly galled by an ill-fitting saddle, I would find myself for many hours entirely alone picking my way by the light of the moon, the poor brute I was riding not being able to keep pace with the rest. All the following day our route lay over stoney plains of a bolder type than any we had yet seen, and when in the heart of

the Hadendowah hills we came suddenly upon a scene in its weirdness the most extraordinary and most appallingly grand I had ever seen. A huge wilderness lay before us like the dry bed of a vast ocean, whose waters by some subterranean convulsion had been sucked into the bowels of the earth, leaving in its whirling eddies the *débris* of submarine mountains heaped up in rugged confusion, or scattered over its sandy bottom. Porphyry and black granite boulders, in every conceivable form and size, lay strewn over the plain. Sometimes so fantastic did their shapes become, that the least imaginative of our party could picture the gigantic ruins of some mighty citadel, with its ramparts, bastions, and towering castle. For many hours we were traversing this weird and desolate valley, and when the sun cast long shadows across our track as he sank to rest, his ruddy light falling upon the dark boulders, polished with the sand storms of thousands of years, stray pieces of red granite would catch his rosy glint, and sparkle like giant rubies in a setting of black pearls.

We found more life in ten miles of the Hadendowah country than during the whole of the first part of our journey. Flocks of sheep, goats, and oxen, passed us coming to the wells, or going to some pasturage up in the hills, but few natives came near us, and there were no signs of habitation anywhere. The wells we now passed were mere water holes similar to those met with up country in Australia. The flocks of the natives would hurry down at eventide and drink up all the water that had percolated through the sand during the day, befouling the pools in every conceivable way. Natives seem to revel in water contaminated by all kind of horrors. They wash the sore backs of their camels, bathe their sheep, and drink from the same pool. At one large hole round which a number of natives were filling their girbas we halted, and procured some of the liquid which was muddy and tepid, but wholesomer. A native caravan had camped near by and the Hadendowah escort of spearmen crowded round us.

The Fuzzy Wuzzy is a much more pleasant object when seen through a binocular than when he is close to you, his frizzy locks are generally clotted with rancid butter, his slender garment is not over clean. He is a very plucky individual as we know, thrifty and lives upon next to nothing, but many live upon him. Several grey-beards came up to salute their sheikh who was travelling with us, and this they did by pressing his hand many times, and bowing

low, but they glanced at us with no amiable eyes, and sullenly turned away. There was no absolute discourtesy, they simply did not want to be introduced. Probably they remembered the incident at Tamai, where many of their friends were pierced with British bullets, so they slung their shields, trailed their spears and turned away.

My camel had much improved by gentle treatment and I was able to ride on ahead; just as I neared the narrow neck of the Tamai Pass, two men and a boy climbed down towards us from a small guard-house, on a lofty rock to our left. My camel man and I instinctively came to a halt, for the manner of the comers who were fully armed was impressive. They confronted us and immediately began questioning my camel men, after much altercation, during which I quietly leant over my saddle and unbuttoned my revolver case, for they looked truculent and somewhat offensive. My camel man mysteriously felt about his waist belt, and eventually handed something to the foremost native, whereat he and his companions turned and began to reascend the hill. As we went on our way, I inquired the reason of the men barring our path. "Oh," my man said, "it is simply a question of snuff." "Snuff," I exclaimed, in astonishment, "Yes, that was all they wanted, a little tobacco powder to chew." Here was a possible adventure, that seemed as if it were going to end in smoke, and snuff was its finale.

After all the Suakim-Berber road, that was looked upon as full of dramatic incident—for even our military friends in Berber, when they bid us good-bye said, "It was a very sporting thing to do. Great Scott! They only wished they had the luck to come along"—was a highway without even a highwayman upon it, and apparently for the moment as pleasantly safe, minus the hostilities *en route*, as the road from London to York. From the top of the Tama Pass, 2,870 feet—though of the same name not to be confounded with the famous battle which took place further south—we began to make a rapid descent, and the last sixty miles of our journey were spent in traversing some of the most lovely mountain scenery I think I have ever visited. Sometimes one might be passing over a Yorkshire moorland, with its purple backing of hills, for the sky was lowering and threatened rain. Then the scene would as quickly change to a Swiss valley, when on rounding the base of a spur, one would strike a weird, volcanic-torn country whose mountains

piled up in utter confusion like the waves of the stormy Atlantic; and further on we would come out upon a plain once more scattered with gigantic boulders of porphyry and trap, out of which the monoliths of ancient Thebes might have been fashioned.

On the morning of the tenth day out from Berber we sighted the fort and signal tower of the Egyptian post at Tambuk, on a lofty rugged rock, standing out in the middle of an immense khor. This was practically the beginning of the end of our long journey, and here we rested a few hours, once more drinking our fill of pure sparkling water from its revetted wells.

About half an hour in a north-easterly direction, after a continual descent from the Egyptian Fort, we noticed, at intervals between the hills in front of us, a straight band of blue which sparkled in the sunlight. At this sight I could not refrain from giving a cheer—it was the Red Sea that glistened with the sun—for it meant so much to us. Across its shining bosom was our path to civilisation and its attendant comforts, which we had been denied for many a month. Night found us steadily descending towards the seaboard, as we neared Otao, in the vicinity of which we were to bivouac for the night. My camel nearly stumbled over an old rusty rail thrown across my path, and further on I could trace in the moonlight the dark trail of a crazy permanent way with its rails all askew.

We were passing the old rail head of the Suakim-Berber Railway that was started in 1885. I wondered, as I followed fifteen miles of this rusty line a gradual slope of 1,300 feet towards the sea, whether the road I had only just traversed had ever been surveyed for a railway, and whether anybody had the slightest notion of the difficulties to be contended with in carrying out the scheme. Of course modern engineering with such men as Sir Benjamin Baker at the fore can overcome any difficulty if money be no object, but who can possibly see any return for the enormous outlay an undertaking of this kind would entail?

To start with there is one up grade of 2,870 feet within forty miles from Suakim, and the khors, through which the railway must wind, are sometimes raging torrents. To obviate this if the line be built of trestles (timber elevations) as with the Canadian Pacific Railway, there is no wood in the country but for domestic purposes. Material, for every detail, must be imported. A smaller matter, but also somewhat important, though water apparently

can be found in the khors for the digging, it is a question whether a sufficient quantity can be got at all times for the requirements of a railway. The natives themselves are often very badly off for water, as in the case of the Obak wells.

Wells run dry at odd times in this country, and can never be depended upon. Of course water can be condensed at Suakim and stored. Further a rival line is already in progress, which will connect Wady Halfa with Berber early this year. European goods coming by that line from Alexandria would be free of the Suez Canal dues, and certainly the directors of that line would treat freights favourably if Suakim should ever be connected with Berber by rail. As for the interior trade of the country, nearly all the population have either died from recent famine or have been killed off in the Mahdi's cause. There is no commercial centre or even market to tap from one end of the road to the other.

The next morning we came in view of Suakim, the city of white coral, with her surf-beaten opalesque reefs stretching as far as the eye could follow. It seemed strange to me to be peacefully moving towards her outlying forts, for when I was last in her vicinity one could not go twenty yards outside the town without being shot at, or running the gauntlet of a few spears. But, here I was, slowly approaching its walls, accompanied by some of the very men who in those days would have cut my throat without the slightest hesitation. Suakim had changed much for the better; her streets were cleaner, and mostly free from Oriental smells. But these sanitary changes always take place when British officers are to the fore. Surgeon Captain Fleming is the medical officer responsible for the health of the town, and he has been instrumental in carrying out great reforms, especially in doing away with the tokuls and hovels, in which the Arabs herded together, and removing them to a special quarter outside the town.

The principal feature about Suakim to-day is its remarkable water supply. In 1884 our troops had to depend on condensed sea-water supplied from an old steamer anchored in the harbour, and the town folk drew an uncertain supply from the few wells outside the town. But now Suakim never wants for water, and that of the best. She even boasts of a fountain in the little square opposite the Governor's house. Engineer Mason is responsible for this state of efficiency, to which Suakim owes much of her present immunity from disease. During

the last twelve years immense condensing works have been erected on Quarantine Station; but, better still, about two years ago Mr. Mason discovered an apparently inexhaustible supply near Gemaiza, about three miles from the town. There is a theory—which this water finding has made a possible fact—that as coral does not grow in fresh water the channel which allows steamers to approach close up to the town, through her miles of coral reefs is caused by a fresh water current running from the shore. However, on this theory Mason set to work and found a splendid supply at Fort Charter; an excavation in the khor there, about two hundred feet long and forty deep, is now an immense cistern of sweet water, the result of which the machines condensing a hundred and fifty tons of water a day, are now only required to produce one-half the quantity, saving the Egyptian Government a considerable outlay.

The natives look upon Mason as a magician, the man who turns the salt ocean into sweet water. But metal refuse, scraps of iron, old boiler plates, under his magic touch, are also turned into the most useful things. For instance, the steam hammer used in the Government workshop, is rigged on steel columns, from the *débris* of an engine room of a wrecked vessel. The hammer is the crank of a disused shaft of a cotton machine, the anvil is from an old "monkey," that drove the piles for the Suakim landing stage in 1884, the two cylinders are from an effete ice-machine, and the steam and exhaust pipes come from a useless locomotive of the old railway. A lathe, a beautiful piece of workmanship, is fashioned out of one of the guns found at Tamai. And the building which covers these useful implements was erected by this clever engineer, in the Sirdar's service, who had utilised the rails of the old Suakim-Berber line as girders for its roof and, in my humble opinion, this is probably the very best purpose for which they can be used.

DISCUSSION.

The CHAIRMAN said—The instructive paper to which we have just listened calls for very little discussion on our part and, therefore, I have no special observations to submit to you as regard to it, although it is my pleasing duty as, Chairman, to offer the sincere thanks of our Society to Mr. Frederic Villiers for giving us so much pleasure and so much informa-

tion in respect to a part of the world which is at present one of considerable interest to this country. It is impossible not to admire the courage and nerve of a man like Mr. Villiers, who has been through every campaign of importance that has taken place during the past twenty years; in the course of which he has been under fire about a hundred times, although happily for his country without being wounded. No doubt he has had, on many occasions, to "screw his courage to the sticking place;" but it is fortunate, I think, for himself and for us, that his head has been screwed on in the right way, and that it still remains screwed on after many hairbreadth escapes. As one who has in former years seen some active service in the field, I can bear personal testimony to the arduous character of a war artist's and correspondent's duties in campaigns; duties at times exceeding in their variety and difficulty even those of the "fighting line," and duties, therefore, justly entitling Mr. Villiers to the many medals and decorations which have been so well bestowed upon him. The question of the best route to Khartoum is one which has occupied public attention very keenly since 1884. In this matter we have all listened with respect to the views of one who has traversed both routes. Happily, the question has ceased to be a burning one, inasmuch as the present operations against Khartoum are likely to be carried on by means of both the Suakim and the Nile routes, the latter being no doubt, at the present moment, the superior one, seeing that it has been improved and shortened by the railway that is being constructed from Wady Halfa to Berber with so much skill and energy by the Royal Engineers. Although Mr. Villiers has truly said, on a recent occasion, that "it is civilisation that kills," and that the "warpath with all its perils and hardships is the thing that keeps a man best up to the work," I hope he will be able to take a little rest in his Cricklewood paradise before he joins in his twelfth campaign, viz., that which seems likely to come off before Khartoum within the next few months. We shall all wish him God speed in any duties that he may undertake, with a hope, moreover, that he will keep his head well screwed on, and his nerve intact, up to the last.

The vote of thanks having been carried unanimously,

Mr. VILLIERS, in reply, after thanking the Chairman for his too eulogistic remarks, said he feared he must have been imperfectly heard as he was suffering from a bad cold. He found that everybody had colds in England, and he would advise sufferers from such affections to try a campaign in Egypt. He feared, if he remained in a civilised land, he should die early, and therefore, though he was by no means a bloodthirsty man, he hoped there would always be plenty to do for war correspondents, even if it were a peaceful campaign like the last one in the Soudan.

INDIAN SECTION.

Thursday, January 20, 1898; the Right Hon. LORD GEORGE HAMILTON, M.P., in the chair.

The CHAIRMAN, in introducing Sir M. E. Grant Duff, said he was known to many present personally and to all by reputation. Thirty years ago when he first made Sir M. E. Grant Duff's acquaintance in the House of Commons he had already acquired the reputation of being one of the best informed and most critical of Parliamentary speakers, and since then he had filled a number of high official posts with distinction, culminating in that of Governor of Madras. He was well known in connection with many branches of literature and science, and was gifted with an almost omnivorous power of reading. There was nothing in the world about which he did not know something, and of many subjects he knew a great deal. As an official he (the Chairman) had been struck by the extraordinary use Sir M. E. Grant Duff made both of his eyes and ears in picking up all sorts of odd pieces of information, recording and annotating them, and being able to give them out afterwards with very pleasant effect; in fact he had the reputation of being an excellent *raconteur*. They must, therefore, anticipate that the paper he was about to read would be full both of instruction and of amusement.

The paper read was—

RECREATIONS OF AN INDIAN OFFICIAL.

BY THE RIGHT HON. SIR M. E. GRANT DUFF,
G.C.S.I., F.R.S.

About half a generation ago, Professor Max Müller delivered a lecture at Cambridge, to which he gave the title of "What can India teach us?" In it he dwelt, as might have been expected, chiefly on the insight into human history and into the working of the human mind in the formation of language, which has been derived from the study of Sanskrit. I think it is very likely that this lecture was in the minds of the authorities of your Society and of the distinguished Indians with whom they took counsel, when they asked me to address you to-day; and undoubtedly when the subjects with which my eminent friend dealt have been eliminated, there still remain a vast number of things which India has to teach us. First and foremost of these are, of course, the science and art of government. I remember when I went to the India Office, nearly thirty years ago, and began, after a week or two of bewilderment, to understand something of the work in which

I had been called to take part, I felt that it was indeed widely different from that which had fallen to the lot of some of my colleagues in the Administration. One was entirely absorbed by the Navy; another by the War Office; a third by elementary education; whereas I found spread out before me the whole government of an empire alike in its internal and external relations. That was an excellent training, and reconciled me to some disappointments. It would be idle, however, to attempt to say anything to-night about Indian government, and I have said as much as I care to say, for the present, about it, in many ways and in many places. It is not that side of Indian teaching on which you wish me to speak. You wish me, I understand, to speak of some of the things which one learns incidentally by living in India if one only makes a reasonable use of even very indifferent eyes. And this I shall attempt to do, carefully avoiding the ground which Professor Max Müller has traversed. Even after passing that self-denying ordinance, there is an *embarras de richesses*.

The difficulty is to know where to begin. Many people would begin with sport, but about that I know absolutely nothing. My sympathies, save in the case of man-eating tigers and such-like, are, I am afraid, with the four-legged as against the two-legged mammal. Anyhow I subscribe to the doctrine of the late M. Van de Weyer. That eminent scholar, collector, and diplomatist was once asked by one of those excellent but rather tiresome hosts who insist on sending this man to fish, that one to shoot, and so forth, "Now Mr. Van de Weyer what can I do for you?" "Oh! thank you," he replied, "I don't want to kill anything; not even time." Science owes, nevertheless, a great deal to the sportsmen who in pursuit of their pleasures have accumulated a great many facts which have now been collected and registered in such books as Mr. Sterndale's very pleasantly written and informing "Mammalia of India."

Those who are not sportsmen see but little of their four-footed neighbours in that country; their avocations keep them for the most part in places too near the haunts of men to be agreeable to creatures whose natural homes are uncultivated wastes or woodland solitudes.

I myself saw very few, although I kept a good look out while travelling. I have come on the recent tracks of wild elephants in the forests of Travancore, but I never saw the creature in its natural state. Nor had I any better fortune with the tiger or with the panther,

which we know in South India as the *cheetah*, although both the last-named animals claimed a certain amount of my attention, even officially. I remember being much delighted with a letter which came before me in connection with some orders we had issued in consequence of having it brought to our notice that in an outlying portion of the Vizagapatam district the tigers "had increased, were increasing, and ought to be diminished." A police officer, writing to his immediate superior, told him that, shortly before, while strolling about in the evening, armed with only a shot-gun, he had suddenly found himself in the presence of a fine tiger. "My old spaniel," he added, "immediately recollected that he had pressing business at home, and I followed him to see what it was."

I recollect, too, another incident that was brought to my notice in the course of business, in which a panther figured. A postman in the discharge of his ordinary duties was passing through a piece of jungle in the little State of Sandur, which lies surrounded by our district of Bellary, when one of these creatures dashed down upon him, tore open the letter-bag which he carried on his back, and vanished. You may form your own opinion as to whether his object was or was not to select the particular letter he desired to read; but if you do, I trust you will consider it as another proof, if any were wanted, of the great extent to which the schoolmaster has been abroad in the territory of Fort St. George and its dependencies.

I once, when walking at Ootacamund with our Surgeon-General, Dr. Bidie, one of the most intelligent, well-informed, and agreeable of all my Indian friends, saw the *Paradoxurus Zeylanicus*, not a very common animal in Southern India, though met with very frequently on the other side of the Straits of Manaar. Its far more familiar relative, *Paradoxorus musanga*, the toddy-cat, I never actually saw, though we once occupied the same room at Calicut, he preferring the roof while I preferred the floor. The scientific name of these creatures is rather a reproach to the wise, for they go through the world under the imputation of having something paradoxical about their tails, which they have not got. It so happened that the particular animal from whom the genus was named had his tail twisted up from having been kept in a space too confined, and the zoologist who gave the name jumped to the conclusion that the peculiarity belonged to the whole race. Such mistakes are made sometimes, even by the wisest of the wise.

There is a bird in Madras which is known as the dayal. Linnæus, confusing *dayal* with the English *dial*, called it *Copsychus solaris*; solaris got miswritten saularis, as if it had something to do with the French *saule*, a willow. So *Copsychus saularis* is and will, I suppose, continue to be the creature's name.

I once, and only once, saw the Indian wolf *Canis pallipes*. He was engaged, oddly enough, in chasing a deer, not at all far from the house, in the park at Guindy, but the jackal, *Canis aureus*, was, of course, a much more familiar object.

The pretty little *Cervulus aureus*, or muntjac, known in the absurd Anglo-Indian nomenclature as a jungle-sheep, because it is a true deer, just as the *Gazella Bennetti* is known as a ravine deer because it is not a deer at all I have seen in the sholas of the Nilgiris. I need not enumerate the other mammalian creatures which I met with in a wild state. I made a careful list of them, but I do not think I should be far wrong if I were to say that it did not contain above a couple of dozen.

On the other hand I made the acquaintance of some interesting Indian animals in the capacity of pets or semi-pets. We had a baby elephant whose ways were very attractive, but he had, alas! the fate of those whom the gods love, and died at the very outset of his career.

We had a young sloth bear, *Ursus labiatus*, and a most amusing beast he was, very much attached to his keeper, and amiable with other people, so much so that my wife could take him out walking in the park which surrounds Government-house at Madras. I think the period of his life he liked best was that which he spent at Ootacamund, where his delight was to discover, drag to light, and devour the huge grubs which, concealed under the ground, did much mischief to the roots of the grass on the lawns. The female of this species is a very fierce and dangerous creature, using her claws with terrible effect in the jungle, but the head of the family is peaceable and well disposed.

A far less amiable pet was a porcupine, *Hystrix leucura*, nearly allied to the European species, and not an uncommon animal on the Nilgiris, where I frequently found his quills in my walks, though I never saw one wild. He never became at all tame, and his idea of saluting his visitors was to turn away from them and then charge backwards, a manœuvre which would have produced the most highly unpleasant results if they had not been warned of his manners and customs. I remember writing about the tactics of his family to

Kinglake, one of the best and most faithful of my correspondents when I was in India. His reply was eminently characteristic :—

"To me, with the habit (that chance has forced upon me) of considering war subjects, there is what used to be called a 'profound moral' in the tactics of the porcupine you speak of; your porcupine knew, I suppose, as his ancestors knew *ab initio*, that fated lesson which man never learnt quite completely, until modern times, the lesson which teaches that, although one's *motive* may be really and truly defence, the means to be employed must be *aggressive*, not merely resisting. It is a lesson of very great import to the human race, and seems to put off till the Millennium all notion of peace being other than, what Hobbes I think called it, a state of preparation for war."

We had at Guindy and elsewhere great numbers of the pretty antelope, common in most parts of India, and familiarly known as the black buck. They were very timid even in the park of Government-house at Madras, where so many people were always coming and going. I once saw a pretty large herd fly from a little Yorkshire terrier, weighing about 6 lbs.; but it is right to say that they eventually took heart of grace, faced their pursuer, and drove him in headlong flight. We had abundance, too, of the beautiful *Axis maculatus*, of which Sterndale says, "that spotted deer and lovely scenery are found together," at all events, in Central India—like apparently drawing to like. Of the huge sambhar, we had only one specimen, but she was much respected, and used to take her walks abroad accompanied by two servants. She was a grand creature, though not nearly so beautiful as the *Axis*, and deserved to be connected by her scientific name, *Rusa Aristotelis*, with the "Master of those who know."

Any one who had good eyes might make the acquaintance of a considerable number of birds in Southern India, more especially on the hills. Mr. Davison, an excellent ornithologist, who lived near us at Ootacamund, told me that he thought there could not be fewer than five hundred species upon the Nilgiris, about as many, that is to say, as are to be found in the whole of Europe. On the high plateau upon which Ootacamund is situated, he thought there might be three hundred species. Many of them, however, were exceedingly shy, and, although I frequently took walks with him, I do not think I could have seen a tenth of that number. Any one, however, who had keen sight and a knowledge of ornithology, might, it is sufficiently obvious from what I have stated, find ample occupation in that pursuit

if circumstances led him to fix his residence in the Sanatorium of Madras. I should gather from what Mr. Davison told me that there was not much difference between the bird population of the Nilgiris and that of the two other important southern ranges known as the Anaimalis and the Palanis; but two birds found close to Ootacamund have, I believe, not been met with elsewhere—the strange-voiced Nilgiri thrush, who is indeed no thrush, but *Trochilopteron cachinnans*, and the pretty little pipet, *Anthus nilgiriensis*.

Between the domain of the pets and of the wild creatures, is that of the inmates of the house and its neighbourhood, which are sometimes befriended, sometimes tolerated, sometimes most justly persecuted. Typical of the first class, are the little palm squirrels, and the mungoses. The former were so tame in Government-house at Madras that they would sometimes come and assist at breakfast, while the latter did much the same at Guindy. These last lived somewhere in the gardens but would eat out of my wife's hand, until she gave a fancy ball there to which one or two native ladies of the very highest rank came. Whether they disapproved of this concession to European manners, or whether they held Puritan principles and disapproved of dancing altogether, I know not, but they did disappear from that day forward. To the second class belongs the so-called musk rat, which, by the way, is not a rat at all but a shrew, *Sorex ceruleus*, which deserves to be more kindly treated than it often is, and the lizard, known (heaven knows why) as the blood-sucker, who ought to be very much encouraged as being a foe to many dangerous and disagreeable animals. To the third belongs a host of detestable things, from the scorpion down to the mosquito. Any person newly arrived in India, who wants to get the maximum of pleasure and minimum of unpleasantness out of all these, and many other neighbours, may be safely referred to two delightful books, "In my Indian Garden," and "Tribes on My Frontier." Most truly does Sir Edwin Arnold say in his preface to the first of these :—

"They are only sketches, no doubt, which fill this little portfolio, but their outlines are often drawn with so true a hand, that nothing can be more suggestive to the memory of any one who has lived the same life. India may be hot, dusty, distant, and whatever else the weary exile alleges when his liver goes wrong, but she is never for one moment, or in any spot, as regards her people, her scenery, her cities, towns, villages or country places, vulgar. There is nothing in her not worth study and regard; for the very stamp of a vast

past is over all the land. Our author is one of the happy few in whom familiarity with Indian sights and objects has not bred indifference, but rather suggested the beginnings of a new field of Anglo-Saxon literature. If I am not wrong, the charm of looking at these utterly common-place animals and people of India in this gay and pleased spirit is, that we get that freshness of feeling which youth alone enjoys when all the world is new to it, interpreted by the adult and matured mind, suddenly entering a practically new world, for such India is to the English official on his first arrival."

As for the snakes of India I did not court their society, and to do them justice they rarely obtruded it upon me. Guindy had been little inhabited for some time before I arrived there, and the cobras had made themselves all too comfortable in an old *Agave* hedge. The hedge, however, was grubbed up and its tenants disestablished if not slain. I did once find *Echis carinata*, an extremely ugly customer, coiled up on some steps in the middle of the house; but he made no hostile demonstrations, and speedily went where the good vipers go. *Hypnale nepa* was more frequently seen, but he is not, I suppose, much more dangerous than the adder of our own heaths, who is, however, by no means a pleasant person. The dreadful Russell's viper I have seen in the park at Guindy, but never near the house, and although I have been in his haunts I never encountered *Ophiophagus elaps*, strangely named the Hamadryad, the only Indian snake who attacks unprovoked. There is an exceedingly amusing passage in the late Count de Hübner's delightful book, "A travers l'Empire Britannique," in which he describes his horror when, as he was walking with me on his first evening at Guindy I suddenly dived across a grass plot when the dressing-bell rang, he feeling himself obliged to follow, in the full expectation of receiving his death-warrant. He did not, however, and long before he closed his honoured life I am sure he thought better of the Indian *Thanatophidia*, and could contemplate with pleasure their counterfeit presentments in Sir Joseph Fayrer's beautiful book. To Europeans in India the wild bee is more dangerous than the snake.

With the fish of India I made no acquaintance, save at dinner. The seer and the pomfret, which are more often seen than any other species at Madras, seem to me to have no great merit. The former, indeed, tastes more like boiled paper than anything else. I once saw some red mahseer, to which a semi-sacred character was attached, in a river of Travancore,

so very desirous of obtaining crumbs that they positively came on dry land, but I never met, as did a man whom I knew well, one of the finny tribe taking a walk in the grounds of the Madras Club. That creature of strange tastes, I think, belonged to the genus *Ophiolepis*.

I have never given any attention to entomology, but there are parts of India in which butterflies are so beautiful that, I am sure, they must afford keen pleasure even to persons as perfectly ignorant of that science as I am.

I read the following in a work by Major Marshall:—

"In insect life, both in size and beauty of individuals and in prolific luxuriance of numbers, the tropics easily bear off the palm, the largest and most beautiful of European butterflies sink into insignificance beside the Ornithoptera, Morpho and Thaumantis of the tropics, while, perhaps, few sights in nature are more strangely beautiful to the traveller in these Eastern valleys than the patches of damp sand which may be found in torrent-beds in the forests literally carpeted with butterflies of every hue, closely packed together, busily imbibing the moisture from the sand, and, again, as startled by the approach of an intruder, they rise expanding into a cloud of gorgeous colours of every hue. The difficulty in procuring rare species is, in such localities, literally the difficulty of singling them out of a crowd."

I never myself saw anything at all like this, but the park of Government-house at Madras used to be haunted by a most lovely creature, as to whose name I made inquiries, and found that it went through the world under the astounding appellation of *Menelaides Hector*! That excited my curiosity, and I found on looking into the matter, that the Iliad had been ransacked to find names for Indian butterflies. I feel very sure that, whether that work was written by Homer, or as someone said, by another person of the same name, its author never contemplated his fame being spread in that particular way. One of the many things on which I had to congratulate myself when at Madras, was the capturing for that Presidency of Dr. Edgar Thurston, who was, I think, the very first Etonian who, having learnt the rudiments of natural history at Eton, devoted himself to science as a profession. He came out to be superintendent of our museum, which I desired to make an index to all the contents of the Presidency, by the study of which the welfare of its people might be advanced, or human knowledge added to. He fulfilled admirably all his more immediate and obvious duties, but he has also made many explorations, of the greatest value and interest, ancillary to these.

He has recorded them in a number of notes and bulletins, like those issued from Kew, treating for example of such subjects as the marine fauna of the Gulf of Manaar; the Tuticorin Chank Fishery, the birds, fishes, and molluscs of the sacred island of Ramesvaram with much else. Most of the contents of these notes and bulletins appeal only to persons more or less interested in natural history, or in the development of the resources of the Madras Presidency, but some of them are quite sufficiently amusing to appeal to the general reader. I came for example, while examining them, upon the following anecdote:—

“A big spider belonging to the genus *Mygale* (*M. fasciata*?), concerning the bird-eating propensities of which genus there has been a long-standing controversy, was caught by me when developing photographs in an improvised dark room at the Raja's bungalow. Soon after my arrival in Madras, in 1885, a live female *Mygale* was sent to me from one of the districts of the Presidency, on the charge of killing sheep and goats by poisoning them on the muzzle, with a request that I would convict or acquit the accused on experimental evidence. A sheep was accordingly purchased, and the *Mygale* placed in a gauze net which was tied over the sheep's muzzle. For a short time the *Mygale* strolled about, showing no indication of poisonous intent, and then—the sheep put out its long tongue and swallowed her, bringing the experiment to an abrupt termination.”

The absurd fancy thus exploded is one of many of the same sort which spring up and flourish on the soil of India. There is an idea, for example, that one snake is so terribly deadly and so well acquainted with its own maleficent powers that when it has bitten you it goes straight to the nearest burning-ground, climbs up a tree, and from that coign of vantage, sees the last of its victim. I was much puzzled as to what this creature could be, but learnt at length, from Dr. Henderson, an excellent naturalist (who came out to reinforce the staff of one of the colleges in Madras before I left the country, though not like Dr. Thurston and his admirable colleague, Dr. Bourne, in the service of the Government) that it was *Dendrophis pictus*, an animal perfectly harmless to man.

Very few of the higher servants of Government—of the directing staff, that is to say—in our great Indian dependency, with the exception, of course, of persons connected with our museums or with our educational system, are so situated as to be able to derive much amusement from marine zoology; but it is to be hoped, and even expected, that when we have succeeded in giving their proper place

to scientific studies, which are now too great an extent crowded out by literature and philosophy, many natives may not only derive pleasure from this pursuit, but may even be able to advance human knowledge.

The only time I ever had an opportunity of seeing anything of the marine fauna of India was when I was coming south along the West Coast in the surveying vessel, the *Investigator*, which had been put at my disposal by the Government of Bombay, and which was commanded by Captain Carpenter, a most intelligent man, who had been out with the *Challenger*. One of the places at which we touched was the Bay of Carwar, which is, I think, one of the most beautiful spots on which my eye ever rested, and I say so with Palermo and Amalfi in my mind. We steamed some seventeen or eighteen miles out of Carwar, and cast our trawling-net in thirty fathoms of water. We repeated the experiment off Mangalore on the next day, capturing also some surface specimens by other means on the day after that. We were only moderately successful, but I find in my diary the following entry:—

“Amongst the harvest of these three days, were a number of very strange crabs; a variety of corals; a sponge; several shells, familiar enough to me in collections, but which I had never seen in a living state; *Veilella*, a most beautiful sea jelly; a few fish, and a *Radiolaria*, a microscopic object, presenting under a high power the most lovely aspect, and extremely important in the economy of nature, for it gives its name to a vast division of the ocean depths. Captain Carpenter showed me a slide covered with specimens of its deceased kindred, brought up from a depth of 2,200 or 2,400 fathoms.”

We captured, too, a sea-snake. These creatures are so abundant along the shore of Madras, that bathing is out of the question, even if it were not for the sharks; but I do not think I had ever seen one before. It is a curious fact that all fresh water snakes in India are harmless, while all salt water snakes are poisonous. These are, I believe, however, —happily for those who are brought into involuntary relations with them—by no means very desirous of exerting their powers for mischief.

Of geology, I only know just enough to enjoy intensely being in the company of those who are experts in that great science. Only now and then did that pleasure come to me in India, but it did once to perfection, when, on one of my tours of inspection, I had the delightful company of Dr. King, of the Indian Geological Survey. After my return from that

journey, I noted in my diary: "To find a month in which geology has played so prominent a part in my life, I must go back to the days when I travelled with Robert Chambers in Moray, before I was in Parliament." Now and then, too, at distant intervals, I enjoyed brief snatches of the society of Mr. Bruce Foote, another most distinguished member of the Geological Survey.

Southern India, which is the only part of that country or continent which I have seen, except as a passing traveller, is not very rich in the more valuable minerals. I obtained from home the services of a mineralogist to examine some of our districts from the point of view of his science beginning his examination just where the labours of the Geological Survey, which is under the Government of India, not the Government of Madras, had their natural termination, but I cannot say that much came of it.

In precious stones, the only department of mineralogy of which I have made any study, Southern India is exceedingly poor. I say this not forgetting that diamonds are still found from time to time, even very fine diamonds, but although I had our regulations in respect to mining made to the last degree encouraging, no speculators have been found to attempt a serious prosecution of the diamond mining industry.

In 1883, while travelling between Dhone and Thekur, I passed near the point where Dr. King, who was with me, believes the Koh-i-noor to have been found in the alluvium which borders the long level ranges of the Cuddapah quartzites, in all probability washed out of the Kurnool rocks immediately above them. I, myself, possess a rough diamond which is said to have been found at Kurnool and which came to me with a careful and elaborate history, but whether it was found there or not I should be very sorry to determine. The curious tale may very likely have been invented to make me the more inclined to purchase. I often envied my friend Lord Stanmore, who ruled the lovely island on the other side of the Straits. In Ceylon, gemming is quite a recognised form of sport, and next to plant hunting it is the form that would have most attractions for me.

I often tried to tempt out to Madras Sir John Lubbock, with whom I had made a great variety of journeys during Parliamentary recesses. I am sure that he, or any disciples of his who would give themselves seriously to

the study of the pre-historic antiquities of India, would have interesting work for a lifetime. Mr. Bruce Foote, whom I have already mentioned, would be, so far as I am aware, the best man to put such an inquirer on the right road.

Only a limited number of our countrymen who go to India have any interest in, or derive much pleasure from, the vegetation by which they find themselves surrounded. Too many pass it by without giving it a thought; some even slander it. It is probable that several who hear me were acquainted, at Calcutta or Simla, with Sir Nathaniel Massey. If so, they will remember him as a man of conspicuous ability, yet Sir Henry Maine told me that, when on one occasion he was rather running down India, a lady said to him:—"But surely you will admit that the flowers here are charming?" "No," he replied, "they are the only things in the country which do not smell." A more unfair imputation was never made, for Indian gardens are full of very delightful perfume plants.

A small percentage, however, of Anglo-Indians does care about the vegetation of the country, and a still smaller percentage is really interested in botany. Sir Henry Collett, for example, is not only a very distinguished soldier, but also an excellent botanist. His field of fame was Northern India and Burma, and I recollect with infinite pleasure the kindness which he showed me when I spent a week at Simla amidst a flora entirely unlike that of our South Indian ranges. I remember he introduced me to, among other new friends, the genus *Ainslæia*, which bears the name of my maternal grandfather, the author of the *Materia Indica*. In Madras we had Col. Beddome, a very great authority indeed, who was just leaving the Presidency when I arrived; but we had all through my time a fair sprinkling of very good botanists, such as Col. Cox, Dr. Bidie, and Mr. Hollingsworth, over and above those who were transplanted to the Presidency while I was there, such as Professor Lawson, from Oxford, and Mr. Gamble, from Northern India. Both these admirable men of science have since been lost to Madras, the first by death, the second by his being made the head of the Great Forest School of Deyrah. When I first landed in India, in the autumn of 1874, I knew something of the flora of the British Isles, something of that of the Alps, and something of that which is found round the basin of the Mediterranean. Of tropical vegetation, however, outside of the hot-house, I had never

seen anything. During the hundred days which I then spent in the country, I came (beginning with Matheran, on which Mr. Herbert Birdwood has just written so well) to know a little of Indian vegetation at various points from Peshawar in the north, to Tanjore in the south; but of course not very much. I wrote in my "Notes of an Indian Journey," published in the *Contemporary Review*, in 1875, and republished in a volume in 1876:—

"True it is that I have merely scratched the surface of Indian botany. True it is that my eye still continually falls on altogether new objects; but, nevertheless, I can put the people and the scenes I care about in India in their appropriate setting of trees and flowers. I have come to know many of the plants which have poetical or religious associations, and I have seen a very large number of those which are economically and commercially important. This, in a run of little more than a quarter of a year, a very large part of which has been spent in rapid locomotion, by rail, by road, or by sea, and the main objects of which have been political, does not appear to me altogether bad."

It was at least better than nothing, and when, most unexpectedly, I was sent back to the East in 1881, I found the little I had learned very useful, and that I had laid the foundation for a great deal of new knowledge which was very serviceable to me, although I had a good many mistakes and misconceptions to correct.

One of the great pleasures which comes to a European botanist when he lands in a tropical country is that his horizon immediately widens. A great number of Orders of plants of which he knew nothing in a wild state suddenly become familiar acquaintances. I came to know, for instance, the *Ternströmiaceæ*, the family to which belongs the Tea to which Linnæus gave the title of *Thea*, punning upon its Chinese name, because it was so divine a drink, and the *Camellia* which makes our greenhouses so beautiful in this month of January. Then there were the *Meliaceæ*, to which belongs the Neem, constantly with us in Southern India, and the *Bacain* or Indian lilac which we have in Southern India, but which is a far more common tree in the North. There were the *Anacardiaceæ*, to which belongs the omnipresent mango as to which we may say, with more truth, what Bishop Berkeley is reported to have said about the strawberry, that he had no doubt that the Almighty could have made a better fruit, but that he had certainly not done so. There were the curious *Rhizophoreæ*, the Mangrove family, and I know not how many more.

In addition to the Orders, of which I was quite ignorant, there were many of which I knew very little in their wild state, but with which I came to live intimately in many places, and more particularly in the lovely gardens of Guindy, which I found richly stored, and left, I am happy to say, much more richly stored. India is so wide a word that almost every sweeping assertion made about it is pretty sure to be liable to very large exceptions. I think, I may say, however, that in no part of the country which I have visited is the herbaceous vegetation of the plains equal to that of the warmer temperate zone, or even that of our own southern counties. I should much doubt whether any dweller in the plains of India could see a sight such as is presented to the inhabitant of London who will take the trouble to run down in the month of May to Kew Gardens and walk round the railing which shuts off the Queen's Cottage, with its long glades of bluebells.

The nearest approach to anything of the sort which I came across in India was in the little State of Cochin, where, during a walk with Mr. Gamble, I saw in front of me what looked at a distance to my wretched eyes like a patch of exposed rock, but which turned out, as I drew nearer, to be about an acre densely covered with a species of balsam.

On the Nilgiris the *Strobilanths*, a genus allied to the *Acanthus*, which is said to have suggested the Corinthian capital, flower at intervals of a few years in such profusion that some people have quite erroneously imagined that it was their colour which suggested the name of the Blue Mountains. That is a mere modern cleverism, but I have seen the low-growing species, known as *Sessilis*, produce an effect which reminded me somewhat of the English bluebell. Most *strobilanths* in the Nilgiris, however, grow high—some of them very high—and convey, of course, a totally different impression.

On the other hand, nothing with which the temperate zone, even in its warmer regions, makes us acquainted, prepares us for the magnificence of the Indian flowering trees. Neither Southern nor Northern Europe contains anything to compare with the grand *Lagerstroemia regina*, a near relation of our little willowstrife; with the silk-cotton tree, *Bombax Malabaricum*; or with *Cathartocarpus fistula*, the Indian laburnum. That tree in its relations to its lovely and loveable, but far less splendid, European relative, is

exactly typical of the difference between Indian trees and those of our latitudes.

The size, too, of many Indian trees, wholly irrespective of their flowers, is exceedingly impressive. The tallest I ever saw was a silk-cotton tree in Travancore, which cannot have been much short of 200 feet high, but Sir Dietrich Brandis told me that he had seen a pine in Kulu and an *Antiaris*, allied to the Upas tree in Burma, both of which reached 250 feet. I do not know what height may not be attained by some of the Australian *Eucalypti* in the climate of South India if they are allowed to live out their lives. The *Eucalyptus globulus* on the Nilgiri hills grows at the rate of ten feet a year. It is another species of *Eucalyptus*, however, whose dimensions distance that of all other trees if it be indeed true that one of them having fallen across a ravine in Victoria was measured with the result that the portion which lay across the ravine would set upright, have been as tall as the Cathedral of Strasburg, while if a bit knocked off in its fall had been added to it, it would have been as tall as that of Cologne. I will say in the words with which the great conqueror Baber in his memoirs concludes his delightful parrot stories:—"Let the credit rest with the relator;" but it may be recommended as a tale with which to stop too much boasting about the big trees of California.

I always wonder why more Indian woods are not introduced into English cabinet work. Some of them are very beautiful, and very unlike anything one ever sees in this country. Through the kindness of Mr. Gamble, I was able to bring home a small collection consisting of 105 specimens of woods, most carefully catalogued and named by him. These belonged, with few exceptions, to trees to which my attention had been called in various ways, representing only a portion of the very numerous South Indian trees. The case which enclosed them was made of *Gluta Travancorica*, a lovely wood, which, nevertheless, I have never known employed in this country. To the same kind friend I am indebted for another case made of mango wood, and containing the leaves of a great many of the same and other trees, so that at any time I can with little trouble think myself back in the tropics, a result to which I am also helped by having taken into my service for between two and three years, a very careful native artist, who painted for me most of the shrubs and flowers

with which I was surrounded, and which gave me so much pleasure at Madras, at Guindy, and at Ootacamund. I need hardly say that I never dreamt of making a herbarium in India; that would have been wholly out of the question, even if I could have devoted to botany anything more than the fag-ends and corners of my time. The flora of the country afforded me a very much greater amount of relaxation than all other things put together. It made all travelling, which without it would have been sometimes rather irksome, a perpetual source of pleasure, and gave me something to observe on every walk and every ride. There is hardly a page of my diary which does not contain some reference to it—all that I could pretty well foresee, but I by no means foresaw some other bearings of my interest in botany.

I have given to this address the name of "Recreations of an Indian Official" because I hoped that I might be able to place in it, here and there, a sentence which might suggest to many Indian officials at the commencement of their career some line of inquiry which might afford them a certain amount of pleasure. If, however, the official chances to find himself in a high position—above all, if he finds himself in the position of governing an Indian province—these pursuits which I have been treating merely as recreations may take a different character. Again and again I found my work closely knit with one or two of them. When, for example, I received my appointment in the summer of 1881, the very first question which the India Office asked me to consider was that of the state of the Madras forests, and one of the first people whom I saw on the platform when my train steamed into Madras was my old friend Dr. (now Sir) Dietrich Brandis, sent down by the Viceroy to confer with me upon that subject. He remained in the Presidency for a year, and in the closest communication with me. By his help and by that of my colleagues and others I succeeded in putting both legislation and administration on a footing which brought, even before I left the country, additions alike to the prosperity of the people and to the revenue of the Government. On my very first tour of inspection I had to go into a question as to a particular species of cinchona in the Government plantations, about which some, as it turned out, quite unnecessary alarms had been circulated.

After each of the eight tours, in which I visited all of our twenty-two districts hearing

everything that the most authorised exponents of local aspirations had to say, I referred all my notes, all the addresses I had received, and all the replies I had made, to my Departments, so that everything which had struck me, as well as every suggestion that had been made to me, should be thoroughly considered, and every request, if possible, complied with. I gave the Departments nearly a year after the conclusion of the eight tours, to bring all in order, and then called for a report as to every single point that had been referred to them. I then examined all their replies, and drew up, in the shape of a minute, a full explanation as to what had been done, what had not been done, and the reasons for the same. A copy of this document fell into the hands of my old friend Mr. George Venables, who, as all who knew that exceedingly brilliant man, one of the ablest of the Cambridge generation of which Tennyson was king, will remember, was about as little interested in external nature, and about as much interested in men and books, as any one possibly could be. He wrote as follows:—

"I am moved to write to you by having just read your minute of official tours through your kingdom. I had heard of it, but not seen it till Eastwick lately sent me a copy. I have been very much interested in it. It is much pleasanter reading than any other Blue-book I remember, and nothing has given me so clear and, I suppose, so accurate an explanation of the way in which India is governed.

"Your comments on trees and other vegetable products justify the proverb, 'keep a thing for seven years and you will find a use for it.' I should hardly have expected that even in seven years botany would be useful to a statesman."

Again two years later than this, in another paper extending in point of size like its predecessor to a respectable octavo volume, I reviewed everything that had been done during my five years tenure of office, so that if useful things which I started were not carried on by my successors, it should be no fault of mine. Here, too, I find that the subjects on which I have touched to-day have on their graver side a considerable place. It contains, I see, sections dealing with "Agriculture," "Planting," "Forests," "Cinchona," "Horticulture," "Botany," "Economic Plants," &c.

The Governor of Madras is also Chancellor of its University and, before laying down my office, I took an opportunity of addressing to the youths of South India, and more especially to its graduates, such counsel as I

thought most likely to benefit them. The subjects with which I have been dealing this afternoon came, amongst others, under review, and I should like to quote some things I then said with a view to show how I think the study of external nature might be made of value to the youthful native, of much more value than some of the quasi-philosophical speculations in which he is too prone to indulge and which are about as useful as spinning a top or trying to square the circle.

A large section of my counsels related, of course, to the topics of which Professor Max Müller spoke in the lecture I mentioned in the beginning of this paper, and many also to industrial pursuits, but I passed towards the end of what I had to say to the sciences of observation of which I have been speaking this afternoon. With regard to these I said:—

"There is no want of aptitude amongst you for these studies, so dignified and so repaying in point of happiness; I could mention the names of several native friends of mine who show a great turn for them, but I do not think they are graduates.

"The weakest part of our system of higher education has, up to this time, been that which is concerned with the sciences of observation, but the men—Dr. Thurston, Dr. Bourne, and others—I have just mentioned bring into the Presidency the latest methods and results of the most renowned schools in Europe. I doubt not that they will have a pretty tough battle to fight before they get into the minds of the teachers, to say nothing of the pupils, that no science which is not derived from direct contact with nature is good for anything. What is wanted amongst our Indian youth is not a knowledge of what books or professors say about natural objects, but what those natural objects say about themselves. In this, as in many other departments of life, the function of the middleman always tends to become disproportionately great. We want to bring your minds into the closest possible relations with the producers of impressions, that is to say, with the things which you see and touch. No middleman should be employed when the first difficulties are surmounted but your own senses.

"The yearly flower show in Madras furnishes agreeable evidence that the taste for horticulture, if not for botany, has taken some hold amongst the wealthier natives. I trust this taste may go on spreading, for it is at once an indication of advancing civilisation and an agency for advancing it further.

"I might go on to speak of other sciences and other pursuits, but, I hope, I have said enough to show you how many directions there are in which our graduates may usefully employ themselves—not only may, but must—if South India is to prosper.

"It is not by their political machinery that Western countries have prospered, even when that machinery has been well contrived. It has been much more

by ten thousand influences, trade, mining, manufactures, inventions, universities, books, learned societies and what not, combining in one or two exceptionally favoured countries, with well-contrived political institutions. Before the knowledge which we bring you ready-made can have its perfect work, your national life must be enriched in a vast number of ways of which I am afraid a great number of you have not even begun to think. I trust that I may succeed in making you think about them or some of them, for there is a great amount for the most educated class in Southern India to do before they have got for their country that sort of recognition which they ought to get for what is undoubtedly one of the oldest lands in the universe.

"We have in the Madras Presidency very few records of even the secondary formations; but a large part of its surface is covered by masses of crystalline gneiss, which was looking very much as it does now æons and æons before the greater part of England rose from beneath the waves.

"And the immense majority of its inhabitants, although they certainly cannot say that they are as old as the rocks of the Nilgiris, would, at least, if they did so, come very much nearer the mark, than did the great French family, of whom it was said 'noble as the Barrases, old as the rocks of Provence.'

"It is not only an ancient but a beautiful land in which the lot of most of you is cast. There is hardly a district in the Presidency which does not contain scenery which people in Europe would go hundreds of miles to see, and of which the globe-trotter pursuing his way over 'the bare stony wolds of the Deccan,' and the monotonous plains so common in Northern India, little dreams. Such a land well deserves that the best efforts of its inhabitants should be given, first, to make the most of its resources, and, secondly, to illustrate it by leading therein lives which may be useful to the world at large."

I made a point, as in duty bound, of sending to Kew every seed I could think of which was at all likely to be thought either botanically interesting, economically useful, or ornamental there. I say as in duty bound, because I cannot speak too strongly from my experience at the India Office, at the Colonial Office, and as Governor of Madras, of the splendid services which have been performed abroad for the Empire under the guidance of Sir Joseph Hooker and Mr. Thiselton Dyer. From Kew, after they had taken what they wanted, the seeds I sent were dispersed all over the British Colonies and many other lands: Berlin, Cintra, Christiania, Upsala, Orotava in the Canaries, Cambridge in Massachusetts, the island of Grenada, and Mauritius are a few only of the widely-scattered places to which our Madras seeds found their way during my five years.

I had, too, the satisfaction, thanks to the suggestion and co-operation of Kew and to the very intelligent sub-collector of Tellicherry, of introducing the pepper into the West India Islands. It may seem strange that this was left for our own times to accomplish, seeing that the Malabar pepper trade with Europe goes back quite to Roman times; but the difficulties before these days of Wardian cases seem to have been insuperable.

There is no greater mistake than to suppose that because plants are common and familiar objects in the tropics, they are quite sure to be equally familiar even in the splendid hot-houses of Kew. The truth is, that in our cloudy climate tropical plants easily drop out of cultivation, and sometimes there are strange gaps left by the operation of accident. I found, for instance, that the *Borassus flabelliformis*, the Palmyra palm, which is so common in South India, that in the single district of Tinnevely there are said to be 1,000,000 trees, was not represented in our great national collection.

If the paper which I am now reading does nothing more than direct the attention of some of my hearers to Professor Max Müller's lecture, it will not be useless. Those who turn to that lecture will perceive that it directs attention to numerous subjects which lie quite outside the circle of those which I have been bringing before you, and whole leagues away as well from the routine of a young or middle-aged soldier or civilian's life in India, as they are from the great political, military, financial or public works' questions, which absorb so much of the attention of their elders in the official hierarchy. It is really very little matter to what branch noticed, either by Professor Max Müller or myself, the sojourner in India devotes himself in his leisure hours, and I could easily mention some which neither of us has touched on. Supposing, for instance, any one were to determine to master in the first half-a-dozen years of his time in India, Sir Henry Yule's altogether delightful glossary, published under the misleading yet perfectly appropriate title of "Hobson-Jobson," how vastly would he have extended his range of intellectual interests as well as his knowledge of the East.

Madras officials are particularly fortunate in having windows opened for them in every direction by the great *Manual* compiled by Dr. Maclean, a man of real genius. The Indian services are very rich in men of ability, well supplied with men of talent,

but genius is rare in them as it is in most other places.

It is, I repeat, a matter of great indifference to what amusement an Indian official devotes himself, provided it is not some mere silly device for getting rid of a portion of the three score years and ten, which go alas! fast enough, as we all find out when we get towards their conclusion. Well did a wise man lately taken from us say :

"The service of philosophy, and culture as well, to the human spirit, is to startle it into a sharp and eager observation. Every moment some form grows perfect in hand or face; some tone on the hills or sea is choicer than the rest; some mood of passion or insight or intellectual excitement is irresistibly real and attractive for us—for that moment only. Not the fruit of experience, but experience itself is the end. A counted number of pulses only is given to us of a variegated, dramatic life. How may we see in them all that is to be seen in them by the finest senses? How can we pass most swiftly from point to point, and be present always at the focus where the greatest number of vital forces unite in their purest energy?

"To burn always with this hard gem-like flame, to maintain this ecstasy, is success in life. It is only the roughness of the eye that makes any two persons, things, situations, seem alike. While all melts under our feet, we may well catch at any exquisite passion, or any contribution to knowledge that seems, by a lifted horizon, to set the spirit free for a moment, or any stirring of the senses, strange dyes, strange flowers and curious odours, or work of the artist's hands, or the face of one's friend. Not to discriminate every moment some passionate attitude in those about us, and in the brilliance of their gifts some tragic dividing of forces on their ways, is, on this short day of frost and sun to sleep before evening."

I know, of course, that there are people who tell us that there are fewer officials who amuse themselves in an intelligent way in India, after their work is over, because that work has now become so very hard. No doubt it is very hard, but at the same time there is a great deal of truth in Goethe's saying "Time is endlessly long, and every day is a vat into which a great deal may be poured if you will only fill it up." It is not to be denied that India, like most other countries, is cursed with too many official returns and reports. Lord Cromer, when he was staying with me in India, told an excellent story *à propos* of the terrible lengthiness of Indian documents, in an after-dinner speech. During the Franco-German war General Blumenthal assembled the newspaper correspondents with the army and said: "Gentlemen, there is too much

writing; if this goes on somebody will be shot; will you come to breakfast, gentlemen?"

I am sure most Indian Governors, Viceroy, and Secretaries of State would like to see their officials imitate the style of that diplomatist who wrote what Lord Palmerston said was the best despatch he ever received: "My Lord, I have the honour to transmit to your Lordship the latest Constitution promulgated in this country. If it is not absolutely perfect it is at least perfectly absolute."

Lest, however, you should say to yourselves that I am sinning against my own advice, I now bring these remarks to a close.

DISCUSSION.

The CHAIRMAN said the audience would, he was sure, all appreciate the interesting and admirable account which Sir M. E. Grant Duff had given of his recreations as an official in India. The paper merited all that he had said of it in anticipation, and touched on subjects on all of which the reader of the paper spoke with accurate knowledge; it was full of trite quotations and apposite aphorisms, and to all it suggested various means of recreation which could be usefully adopted by officials. The reader of the paper's knowledge of botany and natural history was so great that he could not attempt to criticise any portion of the paper dealing with those subjects. Every one present had either been connected with or was interested in Indian government, and it was a question which had sometimes occurred to him, how was it that Indian officials, who wrote so admirably, by the length of their writings so greatly diminished the time available for their own recreation, and that of others who had to read them? Some said that it was due to the fact of Warren Hastings, who was an admirable writer, having a copious style; and, therefore, everyone who aspired to be a Warren Hastings, if he could not equal his writings in ability, at all events imitated their length. Others said it was the effect of the competitive examination system under which young gentlemen who had obtained appointments in consequence of possessing more knowledge than their competitors were placed in isolated situations where they recognised that they knew a great deal more than most of those around them, and, therefore, thought it their duty to thoroughly coach their superiors upon any and every subject on which they wrote. He did not think that quite accounted for it, because he had noticed that however long the original paper of a subordinate might be, the letter of his superior was always longer still. In the House of Commons a gentleman once attempted to control the garrulity of the members by bringing in a Bill to limit the length of all speeches to

ten minutes, but he did not think they would ever live to see the happy day when such a measure would be passed, though it would, no doubt, improve the quality of the speeches; but he hoped some great statesman connected with India would some day be able to get the Civil Service to accept some such self-denying ordinance. A well-drawn up telegram would frequently give all the information required, and the despatch which followed would be ten times as long, and occupy many hours in composition. The only criticism he would make on the paper was with regard to a passage in the early part of it, in which sport was rather summarily disposed of as hardly to be included in the category of useful or profitable amusements. He must say he should be very sorry to see sport eliminated from official recreations. Sport in an Eastern climate with an enervating temperature was a great inducement to people to exercise self-control and keep themselves in condition, and, especially when it was associated with shooting dangerous animals, it tested the eyes, hand and nerve, trained them all to act together, and developed habits of self-reliance and promptitude of decision, which were very valuable. Therefore, although the love of sport might tend to make some people forget or ignore other forms of recreation, he should be sorry to see it put altogether on one side, as it would denote a degeneration in the virile character of officialdom which would be very much to its detriment. Referring to the quotation from Sir E. Arnold, that whatever faults India might have there was nothing vulgar about it, and that the stamp of a vast past was over all the land, he said the object of these papers was that persons interested in India should meet and discuss matters of importance, and, admitting all the grandeur of the past, should try to improve the condition of the people under the British administration, and to bring about a still greater future. Prosperity he did not think ever hardly tested the stability or recuperative power of any great community or nation. It was adversity alone which tested how far it could stand the strain of adverse circumstances. India had recently passed through a rare combination of great difficulties; she had suffered greatly, but under the guidance of the British administration, she was now emerging from the ordeal, and already there were many indications that she possessed a recuperative power which had not been anticipated. He hoped that in the coming period of prosperity they might be able to associate all that was great and good in the past with something greater and better in the future.

Mr. H. M. BIRDWOOD, C.S.I., LL.D., said it would be impossible for him, he feared, to attain to that perfection of brevity which so commended itself to Lord Palmerston in the diplomatic despatch to which their attention had just been directed; still, he trusted he should not be altogether regardless of the caution with which Sir Mountstuart Grant Duff brought to a close his graphic description of the

recreations of an Indian official. He (the speaker) thought he might safely say that most Indian officials would heartily endorse Sir Mountstuart's views as to the multiplication of official returns. The Bombay Government tried some years ago to check the growing evil by suggesting that most returns were useless, as nobody ever read them; but it found itself helpless against the stream of tendency. Complicated figured statements might be a necessity for some statistical purposes, but they were none the less an evil; if, for no other reason, still for the very sufficient reason that official business already weighed so heavily on many of our officers that they no longer had the same leisure for recreation that they once enjoyed. But he was glad to say that, somehow or other, notwithstanding this drawback, many officials still managed to find time for reasonable and wholesome enjoyments outside the routine of their ordinary daily work. He should be very sorry indeed if it were otherwise; for, quite apart from the refreshing and invigorating effect of such delights, or any possible extension of our field of knowledge or any possible gains to science, he thought that our position in India was distinctly improved by the circumstance that so many Englishmen took advantage of the opportunities that arose, in the eight months of the year which they spent under canvas far from the head-quarters of their districts, for enlarging their acquaintance with the country and its people, its natural history, and its great natural resources. If there was one part of Sir Mountstuart Grant Duff's paper in which he found himself unable to agree, it was that part, already commented on by the Chairman, in which he confessed to an imperfect sympathy with Indian sportsmen. His (the speaker's) own belief was that scarcely any occupation brought British officers more closely in touch with the poorer classes of the people or gave them clearer insight into their condition and their wants than the pursuit of big game and other kindred forms of sport, to say nothing of the habits of self-reliance and readiness, strengthened thereby, which must always be a valuable addition to the equipment of every British officer in any responsible position, whether he be an Englishman or an Indian. They had all read Rudyard Kipling's latest story of the Satpura mountains of Central India, which well illustrated the sort of influence that a keen and successful sportsman obtained over the untutored minds of Bhil highlanders, who were all, to a man, above all things, eager sportsmen. They had had officers of the same type in their Khandesh Satpuras, in the Panch Mahals of Guzerat, and the Canara jungles. The names of Ashburner, Probyn, Sheppard, Wise, and Pollen, in Khandesh; of Westmacott, Segrave, Little, La Touche, Propert, and Mulock, in Guzerat; and of Peyton, MacGregor, and Davidson, in Canara; and a host of others were familiar as household words to the brave occupants of many humble homes in those wild regions. And he did not doubt that some of these officers had found the

experience thus acquired in pathless woods, or on the bare hillside, of signal service to them in after years, whether they had been called to such high civil office as had fallen to the lot of one of them—happily with them this evening—their friend, Mr. Lionel Ashburner, or whether they had been entrusted with the command of troops in arduous mountain warfare, as had been the case with General Richard Westmacott, who had so greatly distinguished himself in the Tirah campaign, especially in the handling of native troops. But however that might be, he should like to say that they in Bombay had not neglected those other recreations of which Sir Mountstuart Grant Duff had spoken so instructively. They could claim as their own the author, Mr. E. H. Aitken, of that charming book, “The Tribes on My Frontier,” to which Sir Mountstuart had paid so graceful a tribute. In Mr. Vidal, who had lately retired from the Indian Civil Service, they had an accomplished ornithologist, who was also an authority on snakes. Most of those officers whom he named just now, and some others who were not officials, such as Mr. Inverarity, the eminent advocate, Mr. Barton, Mr. Millard, and many others could tell them a good deal of the habits of various wild beasts. Their knowledge of fishes and of snakes also had been increased by the researches of two most enthusiastic naturalists, the Rev. Father Dreckmann, of St. Xavier's College, and Mr. H. M. Phipson; and their knowledge of plants by such ardent botanists as the Rev. A. K. Nairne, formerly of the Bombay Civil Service; the Rev. Dr. Fairbank, of the American Mission; Dr. Theodore Cooke, the Principal, Mr. Marshall Woodrow, one of the Professors, and his assistant, Mr. Ranade, all of the College of Science at Poona; his own brother, Sir George Birdwood; Dr. Kirtikar; the late Dr. Lisboa, who was not an official, and many others. They could not, indeed, boast of such a rich and extensive museum as Madras had possessed since the days of Dr. Bidie, and he ought to add, since the Governorship of Sir Mountstuart Elphinstone himself, but they owed to the initiative and the exertions of Mr. Sterndale, now one of our Colonial Governors, and of Mr. Phipson, the establishment of a well-stocked museum in connection with the Bombay Natural History Society, which, with its excellent journal, edited by Mr. Phipson, always contained good, readable articles, and was splendidly illustrated, had done much to stimulate the study of natural history in their Presidency, and to help them all to exercise the faculty of observation. With their present appliances, there was every prospect, as Sir Mountstuart would be glad to hear, that those recreations of which he retained so fresh and pleasant a recollection would be shared in and enjoyed by an ever-increasing circle of naturalists in Bombay.

General J. MICHAEL, C.S.I., said that, as a very old member of the Indian Committee of the Society

of Arts, and perhaps, also, as a Madras officer, he had been asked to say a few words. He did so with great diffidence, after Sir Mountstuart Grant Duff's delightful address. He wished that everyone destined for official life in India might read Sir Mountstuart Grant Duff's paper. Most of them in that room were probably more or less interested in one or more of those pursuits of science which he so happily called recreations. An Indian official had opportunities of following any one of them to his heart's content without trenching on the proper performance of his duties. In fact, the man who went about his district business with his rifle, his botanising-box, or his note or sketch-book in his hand, was far more likely to be an efficient public servant, more healthy in mind and body than he who had no such tastes. Sir Mountstuart Grant Duff did not come as Governor of Madras until just after he (the speaker) had left India, so he never had the honour of serving under him; but nearly all of those charming and distinguished officials mentioned in the paper were personal friends of his, and he knew well that one and all of them enjoyed what Sir M. Grant Duff justly called their recreations, not only without detriment to their proper duties, but with distinct advantage to the State and to science. Sir M. Grant Duff's address must recall to many of them happy days gone by. As an old sportsman, he rejoiced to hear Lord George Hamilton and Mr. Birdwood advocate sport as the best possible relaxation for our Indian soldiers and administrators. For himself, his love of sport, natural history, botany, and forestry were to him recreations which lightened a long course of duty in India, and to this he attributed, in a great measure, the health and strength he enjoyed at the age of three score years and ten, and after 53 years of service; while, honestly, he did not think he ever neglected a day's work for a day's recreation. He would not inflict any tiger or elephant stories on them, but as Sir M. Grant Duff had alluded to snakes, and to the *ophiophagus elaps* in particular, he might instance how one may sometimes hear a bit of natural history so startling as to appear quite incredible. Walking in the early dawn along a jungle path below the beautiful valley, named after him, in the Annanulley mountains, with some of the wild men of the district with him, he saw a very large snake, coiled and torpid, just in front of him. On striking it with his stick, he was surprised to see its head rise at the blow, with a hood expanded like that of a cobra. Another blow killed it, and he looked round for his men. They were running away panic stricken, and he had some difficulty in getting them back. They then told him that it was a very rare and deadly snake, which lived on other snakes, and would attack and pursue men without provocation. He accepted this story with a large grain of salt, but as the snake was quite new to him, and 8 or 9 feet long, he skinned it and sent the skin to Jerdon, who was a friend of his. In thanking him for it, and giving him its name, Jerdon wrote that it was the largest he had ever seen, that it was

very deadly, and, fortunately, very rare, and he added, much to his surprise, that it eats other snakes, and was the only really aggressive one known. So that after all, his wild friends knew more of natural history than he gave them credit for. He wondered whether, in mentioning the great interest he took in forestry, Sir M. Grant Duff recollected that this year 1898 was the Jubilee year of the great Forest Department of India, the operations of which had conferred such inestimable blessings on the country and people, and which he fully believed were destined to exercise, in the more distant future, a vast effect for good on the climate, as well as on the water and food supply of India. He begged leave to thank Sir Mountstuart for the great pleasure he had given him.

Sir M. E. GRANT DUFF in reply, after thanking the Chairman for the kind things he had said of him, said General Michael was a very distinguished forest officer, and a pioneer of much good work in that direction. He believed one well-known Indian civilian had been twice attacked by an *ophiophagus*. He need not say anything more, except to emphasize as strongly as he could what General Michael had said about the Forest Department. It was certainly one of the most important in India, and if it were wisely managed, and not indiscreetly pressed in places where such pressure would be dangerous, was likely to be of infinite service to the country.

Sir STEUART COLVIN BAYLEY, K.C.S.I., C.I.E., on behalf of the Indian Section of the Society of Arts, said he had to express how deeply they were indebted to Sir M. E. Grant Duff for taking the trouble to prepare this paper, and also their obligations to Lord George Hamilton for his kindness in presiding.

The following correspondence on the anecdote quoted by Sir M. E. Grant Duff on p. 251 is reprinted from *The Times* :—

“A pleasant story, said to have been told by Lord Cromer, which was circulated by Sir Mountstuart E. Grant Duff, concerning General von Blumenthal and ‘newspaper correspondents’ during the Franco-German war, in the paper on ‘The Recreations of an Indian Official,’ read at the Imperial Institute last Thursday, came upon me with surprise in *The Times* to-day, but, as there seems to be a tendency of late to ‘sit upon the curse of modern armies,’ I hope I may be allowed to deprive the anecdote of any strengthening efficacy in that direction by stating that the veteran chief of the staff of the Crown Prince’s army in 1870-71, General von Blumenthal, never collected the newspaper correspondents, never suggested that if so much writing went on ‘somebody would be shot,’ and, finally, never asked them to come to breakfast. I was with the headquarters of that army from its entry into France, August 4, 1870, til its departure from Versailles in the spring of 1871, and I

am certain no incident of the kind ever took place. General von Blumenthal certainly on one occasion gave a ‘direct hint,’ that certain persons might be ‘shot,’ but they were not newspaper correspondents, but French clericals about Sèvres, who combined political with religious functions, and were not invited to breakfast.

“W. H. RUSSELL.

“January 21.”

“With reference to Sir W. Russell’s letter in your columns of this morning, I beg to say that if Lord Cromer’s anecdote, told in an after-dinner speech at the Madras Club, was incorrect, I regret having repeated it, for I entirely agree with the late Mr. Hayward that the first merit of an anecdote is its truth. No one is more anxious than I to separate the ‘pearls’ from the ‘mock pearls’ of history, but it is not always easy.

“M. E. GRANT DUFF.

“January 25.”

EIGHTH ORDINARY MEETING.

Wednesday, February 2, 1898; Captain W. DE W. ABNEY, C.B., F.R.S., Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society :—

Baker, Charles John Seymour, 47, Redcliffe-square, South Kensington, S.W.
 Bayley, Frederick Roberts, State Railways, Rangoon, Burma.
 Pringle, Hon. John, M.D., Cape Clear, Clonmel P.O., Jamaica.
 Pym, Douglas, Belle Vue Studio, Streatham, S.W.
 Smith, Vere, St. Dunstan’s College, Catford, S.E.
 Wells, Commander Lionel, R.N., Fire Brigade Headquarters, Southwark, S.E.
 Wirtz, Dr. Quirin, M.A., 28, Great Ormond-street, W.C.
 Wright, John, junr., 3, Surbiton Park-terrace, Kingston-on-Thames.

The following candidates were balloted for and duly elected Members of the Society :—

Bosley, Walter Joseph, Sewerage Outfall Works, Guildford.
 Boyd, Captain Mossom Archibald, R.E., Holtcottage, Burton-lane, York.
 Braham, A. C., 9, Broughton-road, Ealing, W.
 Clarke, Stephenson Robert, Borde-hill, Cuckfield, Sussex.
 Cunningham, Thomas C., 23, Queen Anne’s-gate, S.W.
 Doulton, H. Lewis, Lambeth Pottery, S.E.
 Elmer, J. J., Ethelmar-house, Waverley-road, Crouch-end, N.
 Forrester, William, Powell-house, Staplehurst, Kent.

Griffith, William R., Rydal Mount, Upper Bangor, North Wales.
 Hoskins, Nandy W., Invicta-house, Plumstead-common-road, S.E.
 Lawson, Allan John, 25, Canning-road, Croydon, Surrey.
 Liversedge, Alfred J., 32, Victoria-street, Westminster, S.W.
 Macadam, H. E., Ensleigh, High-street, Wanstead, Essex.
 Martin, David, 2, Provan-place, North Montrose-street, Glasgow.
 Mitchell, Charles Frederick, Seeburg, Pennard-road, Shepherd's-bush, W.
 Ransome, John Wilmer, 62, Finsbury-pavement, E.C.
 Rathbone, Richard Reynolds, J.P., D.L., Glan-y-Menai, Menai-bridge, Anglesey.
 Small, William, 294, Camden-road, N.W.
 Speak, John, Kirton-grange, Kirton, near Boston.
 Thudichum, George Dupré, 2, Edinburgh-mansions, Howick-place, S.W.
 Turnbull, R.A., Langham-hotel, W.
 Wheatley, Richard, junr., 42, Brougham-street, Birmingham.

The paper read was on—

THE CINEMATOGRAPH.

By JULES FUERST.

In introducing to your notice the Lumière Cinematograph, I may state, to begin with, that to-day the subject of animated photography is so well known that, strictly speaking, nothing of a novel character is presented to the audience. I need hardly say that animated photographs have come to stay, and before dealing with the Lumière machine and its efficiency in particular, a few historic notes as to the origin of chrono-photography, or the photography of movement, may not be out of place.

In the early part of the century Plateau produced an instrument termed the Phenakistoscope, demonstrating the principles of the persistence of vision, and this subsequently gave rise to the Zoëtrope, or wheel of life, in about 1845. This instrument showed a series of images depicting the successive attitudes of objects in motion.

Later, in about 1870, the Praxinoscope, by Renaut, and the photographic revolver, by M. Janssen (in about 1874) appeared. At the same period M. Muybridge obtained a series of moving photographs taken by means of several dark chambers provided with lenses which were worked electrically at convenient intervals, and I believe this apparatus, or an

improvement on it, was shown before this Society in 1882.* Muybridge and Anschütz, by their photographic studies of animal locomotion, and the exhibition by projection of the results, undoubtedly brought us nearer to the realisation of animated photography as we now know it.

Mr. Friese Greene introduced his camera for taking a series of photographs in rapid succession at the Photographic Convention in 1890, but the extent of its capability was not recognised then, as the pictures were not shown on the screen. Mr. Friese Greene read a paper at that time dealing with the subject of the persistence of vision and its relations to animated photographs.

It was, however, M. Marey (a Frenchman) who gave us the most successful results, having constantly utilised chrono-photography for studying the movements of animals and various physiological phenomena. There were other scientific men who worked in the same direction; it may be said, however, that all these scientists generally sought to produce successive pictures in small numbers constituting an analysis of movement, and destined to be studied at leisure. The reconstitution of that movement, that is to say, the synthesis, was first commercially and practically illustrated on the appearance of the Edison kinetoscope in 1893, but the film on which the photographs were taken having a continuous movement, each picture could not be seen except during $\frac{1}{7000}$ th part of a second, rendering the condition of transparency to light extremely feeble, and consequently the scenes or views had little depth—at least 30 photographs being necessary to leave a sufficiently continuous impression upon the eye.

When Lumière's Cinematograph was first shown in July, 1895, in Paris, the defects mentioned had been removed, the machine permitting the reduction of the number of photographs to 15 per second, any three of which showed movement. The working principle of the apparatus has long been well known, and is the same as with the instruments previously stated, viz., the persistence of the luminous impressions upon the retina, which is easily understood.

If we observe an object, the image in the eye is transmitted to the nervous membrane called the retina. If the object ceases to be illuminated suddenly the image in the retina is progressively removed, and so long as it has not entirely disappeared the optic nerve con-

* *Journal*, vol. xxx., p. 838.

tinues to be impressed, and the eye continues to see the object as if it had remained illuminated. The duration of the persistence of the luminous impression on the retina varies with the amount of light on the object; for a normal illumination it is about $\frac{2}{45}$ second, and is prolonged for another $\frac{2}{45}$ second although the illuminated object may have disappeared suddenly. Consequently if an illuminated object is presented to the eye and masked by an opaque screen during $\frac{1}{45}$ second for instance, its image persists in the eye $\frac{1}{45}$ second, and we do not even perceive its passing eclipse. Let us assume therefore a number of photographs on a film at $\frac{1}{15}$ ($\frac{3}{45}$) second intervals, showing the successive movements of an object; the various pictures obtained are like each other, that is to say, if any two thereof are superposed, the parts which represent the fixed objects are exactly the same, whereas those which correspond with the object in movement occupy positions of which the displacement has been accomplished during the time in which two pictures have been taken. Having said so much, let us assume that we have taken 900 successive proofs during a minute, and let us project the same on a screen by means of any lantern. Let us eclipse image No. 1 by interposing between the luminous source an opaque screen which masks the light during $\frac{1}{45}$ second, and, as we have said, the eye will continue to see the projected image, not only during the whole of the passage of the opaque screen (or shutter), but even after it has passed, during the time equal to the difference between $\frac{2}{45}$ second (duration of persistence) and $\frac{1}{45}$ second (duration of the passage of the shutter), that is $\frac{1}{45}$ second. We will assume then that a second image has been substituted for the image No. 1 when the shutter again un.masks the source of light; we still see during $\frac{1}{45}$ second image No. 1, evidently weaker, but superposed by the image No. 2, and as the immovable parts coincide exactly, our eye perceives the sensation of the moving object, attitude No. 1 succeeded by attitude No. 2.

If we substituted in the same way during successive and rapid periods No. 3 for No. 2, No. 4 for No. 3, and so on up to No. 900, it is evident that the eye sees always the same image in which the moving object passes progressively from attitude No. 1 to attitude No. 900. The eye therefore sees marching on the screen photographs of the object.

It is necessary to have an apparatus to produce thus within one minute the 900 light-

eclipses by which 900 substitutions of successive images are obtained.

In Lumière's Cinematograph these eclipses are obtained by means of an opaque shutter, which revolves at the rate of fifteen times in each second, and is attached so that during its movements it intercepts the light coming from the projecting lantern at each turn, and consequently the illumination on the screen on which the image is projected disappears during a fraction of $\frac{1}{15}$ second. To operate the substitution of images, the 900 successive photographs are made on a flexible film about 55 feet long and $1\frac{3}{8}$ inch wide. The dimensions of each picture are 25 m/m. wide and 20 m/m. long. On either side of the film are perforations (two holes to each picture) at exact distances from each other, into which sprockets periodically penetrate with the object of pulling the film downwards, and displacing it at each passage of the rotating shutter. The sprockets remount immediately in order to attack the next two holes, and so on.

It will be seen that the construction of an apparatus to accomplish such operations must be extremely exact in all its movements in order to keep the fragile film uninjured, and to be capable of using films a great many times.

The Lumière instrument, thanks to the alternate movement given to the crank by an eccentric triangle (which is the fundamental part of the Lumière patent), is to-day the most unique and perfect apparatus of its kind. Thus the rapidity of departure and rapidity of stopping the sprockets is as progressive as possible. The movement of the sprockets does not commence until after the absolute rest of the film, so as to catch the perforation accurately, *i.e.*, not to injure the holes. As a result, the film rests immovable during two-thirds of the time which separates two consecutive phases of reconstituted movement, the other one-third of the time being employed in substituting the following image.

All these advantages considered, the Lumière Cinematograph can be employed with all safety, and furnishes results which no other machine can give, and it is a well-known fact to-day that Lumière's films (taken with the Lumière machine) are used by nearly all those who have machines on the Edison plan, *i.e.*, four holes to each picture, but who cannot obtain with those machines such perfect results. It may be of interest to mention that by adjusting the sprockets in Lumière's machine they take positives with Edison perforation (four holes to each picture).

A few notes on the apparatus may be of interest. The Cinematograph actually is composed of two essential mechanical parts :—

1. The Eccentric Crank.
2. The Sprocket Frame and Sprockets.

Whilst the crank rotates once, the eccentric transmission rotates eight times. The crank is manipulated by a handle which the operator must turn very regularly, about two turns per second, consequently the eccentric transmission will make sixteen turns per second.

The triangular eccentric is fixed behind the transmission, and moves the sprockets continuously in a circle. The movements of these sprockets during their rotation are slightly deformed, so as to engage the film in one case, and in the other case to disengage it. At the end of the crank is fixed a shutter, which is composed of two light metallic sections, which can be regulated so as to increase or decrease the size of the same.

have a tripod, a dark slide, a receiving slide, and a film roller.

The receiving slide is entirely made of metal, and is destined to roll up the exposed film as it is unrolled when photographing.

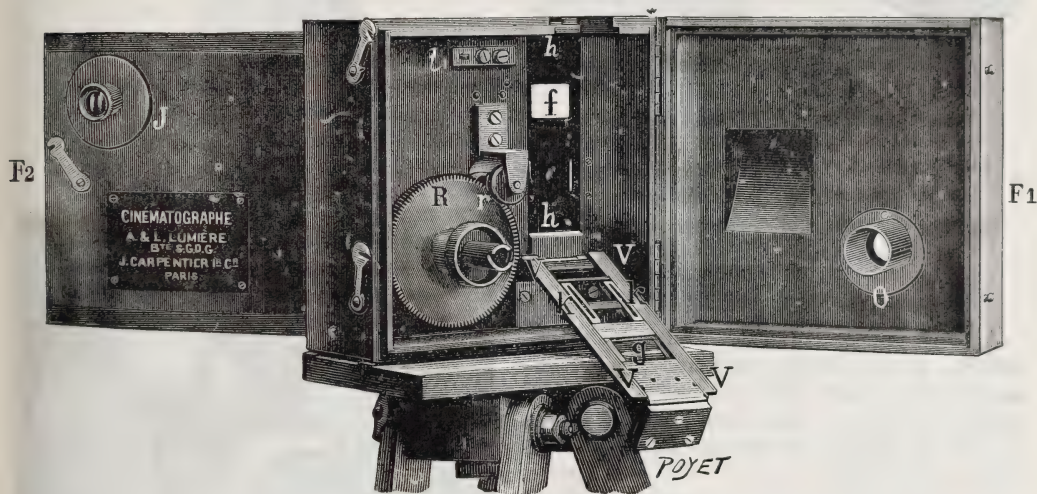
The film roller is used for rolling the film by hand; the film is introduced into a slit on the roller, subsequently rolled, and thus about 50 to 60 feet of the film are rolled in a few seconds.

In taking the negative the following operations are necessary :—

- a. Introducing the film into the dark slide.
- b. Focussing the scene.
- c. Attaching the film to the receiving box, after which the door is closed, and the handle inserted ready to take the scene.

Focussing the object is a very delicate operation requiring all the care of the operator. It is clear that the negative film should have the

FIG. 1.



THE CINEMATOGRAPH CAMERA.

Respecting accessory mechanical parts, there is a bridge-like arrangement on hinges which can be lowered or kept in position by a latch. This bridging has two springs, within which the sprockets play. It has also a square glass provided with springs, which presses lightly on the film when operated, so as to avoid damage to the film in case of any unforeseen accident. The wall is provided with velvet to keep the film from deteriorating, and on the upper part of this wall is a rectangular window, which allows the image to be projected or photographed.

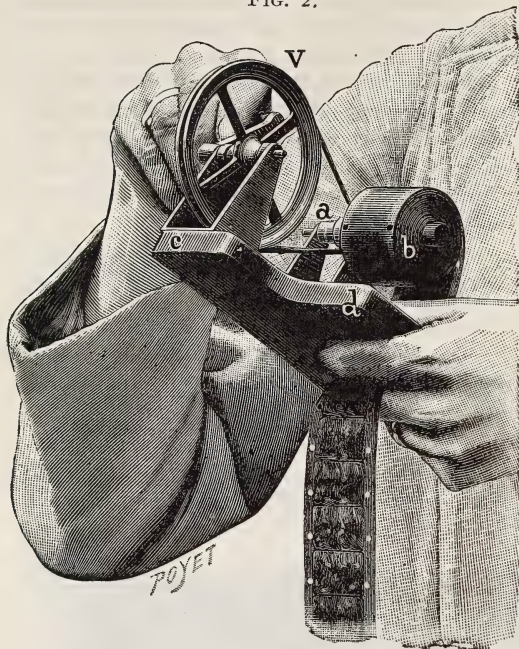
To obtain the negative, it is necessary to

greatest possible sharpness, because the positives obtained therefrom by contact depend on it, and are subject to extreme enlargement when projected. The smallest defects in the negative are very much exaggerated when projected on a large scale.

The negative lens is provided with three diaphragms, one small, one medium, and one large size. The smaller the aperture of the diaphragm, the smaller is the amount of light passed, and therefore the smaller diaphragm increases the general sharpness of the image, and it is recommended therefore to use it when a sufficient amount of light is available.

A small piece of plain matte film will make a very fine ground glass screen for focussing.

FIG. 2.



FILM WINDER.

DEVELOPMENT, WASHING AND FIXING THE EXPOSED FILMS.

Prepare the following developer :—

Water	20 pints.
Amidol	2 ozs.
Sulphite of sodium	10 ozs.

A stock solution of water and sulphite of sodium, which keeps indefinitely, may be always kept ready, and the amidol can be added as required. The relative proportions of amidol or sulphite of sodium may also be altered to suit requirements.

The above quantity of developer is made up so as to enable the employment of ordinary sized galvanised iron pails. It is preferable that these should be enamelled in white on the inner side. For development, take two pails filled with the developer. The film roll is suspended over the pail, and then passed very rapidly into the first pail, and when the end has been reached into the next pail of developer, so as to ensure even development. Care must be taken that the emulsion side is touched by the fingers as little as possible.

We repeat, the operation must be performed very quickly, continuing this process of passing from one pail to another until development is complete. The time occupied by the above

developer is very short. Afterwards plunge the film in a pail of plain water, taking same from the second pail when doing so. Under these conditions development will be sufficiently uniform over the whole length of the film.*

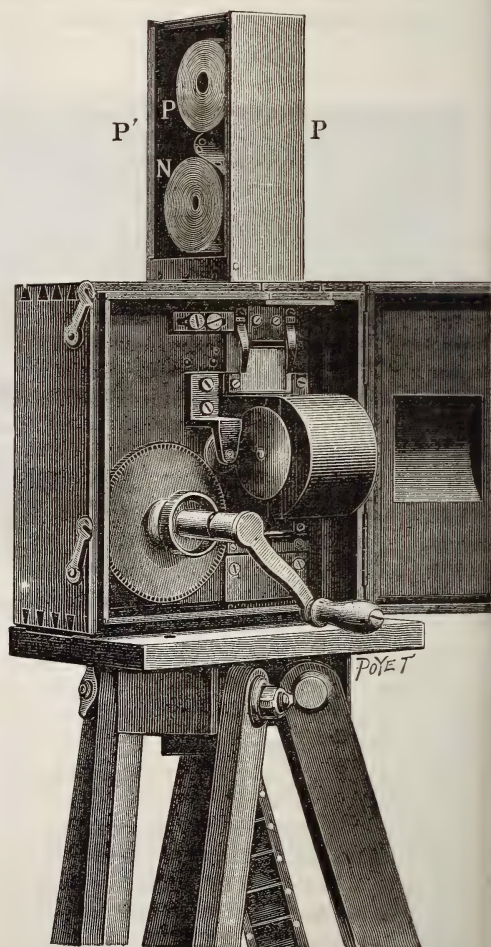
The same operation is repeated in the fixing bath, the strength of which should be one in four. Once fixed, place the film in a receptacle where the water runs continuously, and it must be left in the washing for several hours.

To avoid the film contracting after it has been fixed, it requires glycerining, and the following is the formula :—

Water	15 pints.
Absolute alcohol	5 pints.
Glycerin	10 ozs.

This operation must not take longer than five minutes; the temperature for drying should be 67-70° Fahr.

FIG. 3.



CAMERA AND PRINTING SLIDE.

* There are various other methods and devices for developing, which need not, however, be gone into.

MAKING THE POSITIVES.

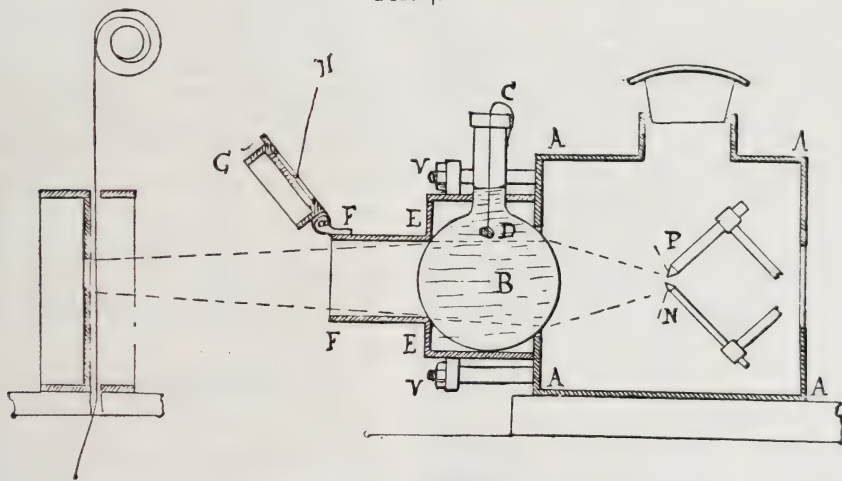
For this purpose a dark slide is used. This dark slide has two axles. On the lower axle the negative is placed emulsion side outwards, and around the upper side the sensitive film, emulsion side inwards. The two ends are passed through the slit in the box. This operation must be done in the dark room. Subsequently proceed to expose the same as for negatives, only with this difference, that the positive film alone is introduced in the receiving slide, whereas the negative film will unroll outside, through an opening arranged at the base of the apparatus.

The shutter must be arranged so as to form a complete semicircle. To make the exposure, close the apparatus, unscrew and remove the lens, and place before the circular opening at a convenient distance, a light, either a gas flame or petroleum lamp. The distance which this light must be placed depends on the nature of its intensity and the density and transparency of the negative. No precise instructions can therefore be given, but a few small strips exposed will give the necessary information to the operator.

water should preferably be distilled, or a few drops of acetic acid may be added. The condenser is cased in a metal frame, fixed with four pins to the lantern, and each having a screw. The casing has a prolongation in the shape of a cylindrical tube, at the end of which is a movable window with a ground glass. This window is opened at the moment of projecting. When regulating the light, turn the globe containing the water until the light is at its maximum. This water globe replaces advantageously the glass condensing lens. As a matter of fact, the glass condensing lens has many disadvantages, and especially that of concentrating the heat rays on the film when same is stationary. By the glass globe this is avoided, as the water absorbs all the heat; and the power of lighting is increased, the light is white, the greenish colouration of the lens being suppressed. Should the water, after say about an hour, begin to boil, it is only necessary to insert a small piece of coke attached to a wire, and the evaporation will proceed with the greatest regularity.

This arrangement avoids any accidents due to carelessness on the part of the operator,

FIG. 4.



SAFETY LANTERN.

PROJECTING.

The additional material necessary for projecting with the Cinematograph is a projecting lens, an electric lantern, resistance coil, a stand, and a screen.

The lantern, containing the regulator, is provided with a condenser, in the shape of a globular glass bottle containing water, which concentrates the light of the arc on to the projecting machine. In order to regulate the carbons, a side window is provided. The

as the concentrating object absorbs the heat rays.

If the projecting is done by transparency, *i.e.*, if the screen is between the spectators and the apparatus, it is necessary to wet the same with glycerine and water in the proportion of 1 in 10. This renders the screen very transparent. These transparent projections give inverse images to those which are projected from the front of the screen.

If it is necessary to re-establish the pictures

on the screen, and to show same in their proper way, that is, from the right, it suffices to turn the film so that the emulsion side is rolled inwardly.

It is hardly necessary to point out that the electric installation should be provided with safety fuses in case the current becomes too strong. We recommend the employment of continuous electric current; it is far preferable to the alternating current, in the latter case the lighting being variable and less brilliant.*

When projecting, the shutter should be placed so that the two discs cover each other exactly. This permits the maximum illumination of the screen, and care should be taken before pictures are shown that the maximum illumination on the screen is obtained from the lantern.

The films must be kept in a state of regular elasticity. For this purpose a tin box is supplied; this box has two compartments. The lower part should have a piece of felt or sponge impregnated with water, over which is placed a wire sieve, on which the circular boxes containing the films (the lids of the same being off) are placed. The films are left like this overnight, and can be used again the next day.

I might mention that, to give the audience an idea of the cost, an outlay of £80 is necessary to acquire Lumière's complete apparatus, capable of taking the negatives, making positives, and projecting and reversing same. This sum also includes a number of scenes or film views, and their number can be added to by purchasing them at a further cost of about £2 10s. each view. These once purchased, and if properly handled, will last for a very long time, and it has been shown that a film is capable of being projected through the machine from 500 to 800 times, thus rendering the working of this machine extremely economical.

In conclusion, I may say there is no doubt that at no distant date those who can afford it will have their animated photographs taken, show them to their friends in their private houses, and then hand them down to posterity. The same may be said of historic events, such as the 1897 Jubilee processions, &c.

[The paper was illustrated by a varied series of animated photographs thrown upon the screen by Mr. Fuerst.]

* It is quite possible, however, to use limelight with satisfactory result.

DISCUSSION.

The CHAIRMAN said it only remained for him to propose a vote of thanks to Mr. Fuerst for his paper. He might say he was the happy, or unhappy, possessor of a Cinematograph, and thanks to Mr. Fuerst he had been able to afford a good deal of amusement to many people with it. One great point about the instrument was the use of a globe of water instead of an ordinary condensing lens for the purpose of concentrating the light on the image. This gave absolute safety, whether with the electric light or limelight, about $\frac{1}{10}$ ths of the heat being absorbed by the water. He might add that it was of no use to add alum to the water, as was at one time supposed. Some years ago he made a number of experiments with regard to the transmission of light through various liquids, and came to the conclusion that there was not a difference of 1 per cent. between pure water and water impregnated with alum. Anyone who examined the mechanism of the Cinematograph would see how beautifully arranged everything was; it was, in fact, the very perfection of workmanship. They were very much obliged to Mr. Fuerst, not only for the very interesting views he had shown to illustrate the capacity of the instrument, but also for bringing to public notice the fact that in this case we had had to go abroad to get a perfect instrument. That was not what he altogether liked, and he hoped that England would yet produce not a rival, but some new instrument which would give perpetual motion without any interval between the views, some great improvement which might be brought before the Society at a future time. However, he was quite satisfied with the Cinematograph, and hoped to make a good deal of use of it during the coming year.

The vote of thanks having been carried unanimously,

Mr. FUERST briefly acknowledged the same, and the meeting adjourned.

Miscellaneous.

ORANGE CULTIVATION IN MEXICO.

It is generally supposed that the Spaniards introduced several varieties of fruit trees into Mexico, among them perhaps the sweet orange, but the traveller in that country, after seeing the numerous forests of wild oranges, inclines to the theory that the ancients knew of this fruit, and that perhaps it was cultivated before the time of Cortez. However, works treating on the history of old or ancient Mexico do not describe oranges; yet, it is to be presumed that the existing wild stock, found generally in obscure and inaccessible regions of the tropics, was placed there originally by the hand of man, and nature spread it widely, but gradually changed it

from a sweet to a sour or bitter orange. The United States Consul-General in the city of Mexico says that the Mexican orange comes under the family *Aurantiacea*, genus *citrus*. Although fifty varieties are known to exist, there are but three kinds of oranges found in the markets of the country, classified as follows:—The sweet orange, “naranja dulce;” the Chinese orange, “naranja de China;” and the sour orange, “naranja de agria.” The “naranja de China” is a small fruit, a little over two inches in diameter, spherical, slightly depressed at the apex, deep yellow in colour, thin, with minute oil cells, and very delicious; its tree is somewhat dwarfish, having small leaves, one inch to one inch and a half long, and resembling those of the myrtle. The sour orange has a roughish rind, rather thick, acrid, bitter pulp, and is generally large in size; its tree is large, having a hard wood, and in many places develops a trunk of great dimensions; the leaves are of a brilliant, agreeable green colour, aromatic, lanceolated, and with a broadly-winged petiole. The sweet orange could be greatly improved, and much could be accomplished with it by careful selection in its propagation—for instance, selecting shoots, cuttings, or seeds from trees, or budding, or grafting with sound stock from California and Florida. There are few countries that possess the natural advantages which subtropical and tropical Mexico enjoys, and hardly any are gifted with the immense proportion of territory, comprising two thirds of the Republic, suitable for orange culture. The greatest producing and most important districts, having easy means of transportation, are La Barca, Ocotlan, and Guadalajara, in the state of Jalisco; Yautepec, Morelos, Linares and Montemorelos, Nurvo Leon; Rio Verde and San Antonio, San Luis Potosi; Guaymas and Hermosello, Sonora; Julia, Tamaulipas, and Coatepec and Cordoba, Veracruz. In Montemorelos and Linares, during the last three years, more than 50,000 trees have been planted with several hundred grafted and budded with California and Florida stock. The Mexican people relish the fruit, and especially on the occasion of the holidays—All Saints’ Day and the Posadas—vast quantities of it are brought into the principal cities for home consumption. Mexico city alone consumes annually more than 300 car-loads of sweet, Chinese, and sour oranges, while Puebla consumes 70, and Guadalajara 30 car-loads. As regards the by-products of the Mexican orange, the leaves (*hojas*) are used for the tea of the Indians and of the poor, and in large cities where they are sold in the streets and in the markets in small bunches for one halfpenny each, are consumed in large quantities. They are considered the best remedy for insomnia and restlessness, and are highly commended for children. A wine is manufactured from the refuse oranges, purchased at about one shilling a hundred in Cuantla, Morelos, and Guadalajara, which retails at two shillings a bottle. There are other valuable products which could be obtained, such as the distilled water of the blossoms, used for toilet purposes, worth about 19s. a gallon;

citric acid from the pulp of the sour oranges; oil from the leaves and rind; and the essential oils from the blossoms, leaves, and unripe fruit. Mexican growers propagate the orange from seed, but it can be reproduced more advantageously by budding, grafting, layering, and from cuttings. The fruit appears, in the latter case, in from four to five years. Budding and grafting have to be practised on grown trees. Propagation by cuttings can be effected from both immature and mature growths. In propagating by seed, a well ventilated place, yet free from cold winds, is selected; the soil must be deep and susceptible of being irrigated. For this process, good vigorous large seeds must be chosen from healthy fruits and best plants. In May the seed beds are made, and in June the seeds, which have previously been kept in earth, are sown 4 inches apart by 8 inches between the rows. The rows can be run with the length of each seed bed, thereby producing 427 seedlings to the seed bed. Having soaked the seeds from 12 to 20 hours in lukewarm water, previous to sowing them, the plants should come up in fifteen to twenty days. If the rainy season has not set in, and on dry days during that season, the seed beds are sprinkled every two days, but when the plant has made its appearance a generous application of water is necessary every day, the amount being decreased as the plant grows. In May the ground is ploughed, cleared of all weeds, and fertilised with cheap manure, having plenty of nitrogenous matter. After the land has been well worked, ditches are run at a distance of about 13 ft. apart, and then cross ditches of the same distance. At the intersection of these ditches holes 2 ft. deep are made for the reception of the young trees; this will give 254 trees to the acre, which can be decreased on a very rich soil, making the distance 16 ft. apart. Great care is taken in transferring the young plants, that they are not in any way injured either in leaf or root. A ring (*cajete*) is hoed round each tree, wide enough to admit manure, and in connection with the ditches referred to above, for irrigation purposes. If it does not rain all day following the transplanting, the plants are irrigated, and afterwards as often as they require it. Two or three days after, if the earth around the plant has settled, loose soil mixed with leaf mould or manure is used to make up the loss. When the trees are mature, dead and ill-shaped branches are removed with the pruning saw, the wound being trimmed with a knife and then tarred over. Wax can be substituted for the tar if the former is not obtainable, and this is done to prevent decay entering into the heart of the tree. Maturity of crop varies very much in Mexico. In Campeachy, Chiapas Oaxaca, Guerrero, Atlixco (Puebla), and Yautepec (Morelos) the fruit ripens as early as July, and the season lasts until December 1, while in Cordoba and Coatepec (Veracruz), in Michoacan and Jalisco until September, Rio Verde and Montemorelos following, and the Sonora crop comes in last, about November 10. The yield in Mexico varies very much—soil, climate, proper irrigation, pruning, and cultivation being im-

portant factors in determining the extent of the crops. In Atlitico, Yautepec, and Tacambaro the trees average 860 oranges each; but in Atotonilco, Montemorelos, and Hermosillo the average yield is from 1,700 to 2,200 oranges a year. With the advantages of climate and soil the tree in Mexico should yield from 5,000 to 8,000 oranges. The tree is not generally subject to any pest, nor is it affected by any disease.

THE WINE INDUSTRY IN THE UNITED STATES.

In the year ended June 30th, 1897, the United States imported wine to the value of £1,372,000, about half of which consisted of champagne and other sparkling varieties. In 1896, the imports amounted in value to £1,421,000. France contributed the greater portion of the wine imports, while Germany came second, followed at some distance by Italy. On the other side of the account, according to a recent United States report, wine production in that country, and principally in California, has already reached such a stage that considerable quantities are annually exported. The shipments of wine—which are chiefly in casks—from the United States amounted in value to £140,000 in 1897, and £135,000 in 1896. A good deal of this wine is sent to Europe, to England, Belgium, and even Germany. Mexico and the Central American States also draw upon the United States for a part of their supply. There are five districts in which the wine industry is carried on: the Eastern, Middle, Western, Southern, and Pacific divisions. The Eastern division comprises a few counties in New Jersey, the Hudson river district of New York, the Keuka district on Lake Keuka, in the central part of the State, the Canandaigua district bordering on Lake Canandaigua, the Chautauqua district near the shores of Lake Erie, which includes some vineyards overlapping the State line, and extending into Pennsylvania. There are other districts aggregating some 10,000 acres in different parts of New York State. The annual output for the entire Eastern division is not less than 2,500,000 gallons. The Middle division includes the States of Illinois, Indiana, and Ohio. The Ohio vineyards are located mainly on the islands in Lake Erie, and on the lands bordering upon the lake. About three-fourths of the grapes produced in this district go to market for table use, and the remainder is pressed for wine. In the so called Western division, the chief tracts are in Kansas and Missouri. In the Southern division there are vineyards scattered throughout Georgia, North Carolina, Tennessee, and Virginia. Grapes are now being produced in some quantities in Florida. It is in the Pacific division that the industry has reached its greatest development. California has made rapid strides in the wine industry, and nearly all the districts there produce grapes. There is said to be an established home demand for wine of the Californian varieties to the amount of 12,000,000

gallons annually, at least. These wines are growing in the esteem of the public. Grapes quite similar to those from which the excellent wines of France and Germany are made seem to thrive well in the Californian climate. A good deal of brandy, and even of champagne, is made, and both red and white wines are produced: sauternes, clarets, ports, sheries, and other well-known varieties. Viticulture was introduced into California by the Franciscan Fathers, but it is only very recently that the industry has assumed important proportions.

DATE FARMING IN PERSIA.

One of the most interesting, profitable, and growing industries in Persia is date farming. The date palm is indigenous in the south, and its cultivation is confined to a district running parallel to the Persian Gulf from the borders of Beloochistan on the east to the Disful river on the west, and extending about 150 miles into the interior. Palm groves, however, by no means absorb the whole of this area; they are chiefly confined to sheltered valleys and plains exposed to a high temperature in the summer, and having a very mild climate in winter. The United States Minister at Teheran, in a recent report to his Government, says that the palm requires a great degree of heat for the ripening and perfection of its fruit, and is, consequently, considering the size of the trunk, extremely sensitive to cold. This arises chiefly from the fact that the vital portion, or that which is most easily affected by outward influences, is the crown or head of the tree. If this be severed or frost-bitten, decay immediately sets in and the plant dies. On this account, the people often consider it the connecting link between the vegetable and the animal kingdoms, and those who cultivate it and depend upon it for support, look upon it with a large amount of veneration and respect. With the most favourable conditions for growth, the plant will not bear fruit under eight or ten years. It attains a height of 50 or 60 feet, and lives more than a hundred years. If, on the contrary, the influences of climate and soil are not suitable, it will produce fruit in four years, but the life of the tree will not be prolonged beyond twenty years, and the fruit is of an inferior quality. The chief requisite for the production of fruitful and profitable palms is a high degree of temperature—not less than 110° Fahr. in the shade. The water and soil should, if possible, show a low per-centage of saline and alkaline qualities, or to use the local term, they should be “sweet.” As rain seldom falls in the southern littoral of the Persian Gulf between April and December, the palms are supplied with moisture by irrigation, and where this cannot be provided the cultivation cannot be undertaken—that is, so far as the Persian area is concerned. It is reported that the date palm will not flourish within a distance of 25 miles from the sea. If this is the fact, it is probably owing to the impregnation of the atmosphere and the

soil with an excessive per-centage of salt, and this would seem to be in accord with the general principles observed in the selection of sites for the groves. A very important point observed in the cultivation of the groves is to have a proper proportion of male and female palms, for unless there be sufficient pollen for the process of fertilisation the plants will be unproductive. It appears from this that some technical knowledge is required for the successful management of the groves. The production of the Persian palms is about 500,000 cwts. per year, nearly half of which is exported to India, Europe, America, and Africa. The dates produced in Persia and shipped from the Gulf ports are hardly equal in size, flavour, and richness to those exported from Bassorah. This is doubtless due to more careful cultivation by the Arabian and Turkish producers. In addition to the consumption of the dates in their raw state by the natives, large quantities are used in the manufacture of syrup, vinegar, and a liquor called "arrack," none of which, however, appear to be articles of exportation.

Correspondence.

RECREATIONS OF AN INDIAN OFFICIAL.

I regret not having been able to take my promised part in the discussion, last Thursday afternoon, at the Imperial Institute, on Sir Mountstuart Elphinstone Grant Duff's paper, as it would have been a pleasure to me to have expressed to him personally my sense of the honour he did the Indian Section of the Society of Arts by so considerably appearing before us, and the enjoyment and zest with which we all heard the lecture. But everything else that I was prepared to say I can say equally well, and better, in the present memorandum.

Botanising and gardening were my all-absorbing recreations in India, and I was always especially anxious to recommend them to young officers, and to ladies, for their amusement. But I found two stumbling-blocks in their way, the unsympathetic, commonplace, and cumbersome scientific names of plants, and the unintelligibility of the popular native names. To get over the latter difficulty I was always seeking for the meanings of the native names, and I have repeatedly appealed to native scholars to bring out a systematically translated list of them; for a pleasant reputation might in this way be very readily acquired. I never got beyond a few hundred, and it is my wish to contribute the most interesting of these to the discussion on Sir S. M. E. Grant Duff's paper, in the hope that my so doing may incite others to complete my casual task.

I write from memory, a memory of inquiries made forty years ago, and without leisure or strength to collate and correct or definitively approve the results of those inquiries. I will only say that I was chiefly

indebted for them to the late Drs. Bhau Daji and Sakham Arjun, the latter the brightest of my students in "Materia Medica," and to the countryside people who accompanied me in my excursions about Mathuran and Mahableschwur. I have arranged my list of the translated names in sections, as this makes it easier to keep them in memory.

NATIVE NAMES OF INDIAN PLANTS.

Section A.—Names descriptive of the general qualities, or of the "habit," of plants.

Akashpavan.—[*Cuscuta reflexa*] "sky-nourished."

Ashokta.—[*Aleurites molluccana*] "root spreading"; a native of the Indian Archipelago, the "Belgaum Walnut" of Anglo-Indians.

Babula.—[*Acacia arabica*] "cover," "shade"; but thought by some to also signify "Babylonian."

Bakhula.—[*Mimusops Eleni*] "crooked."

Bambu, an onomatopœia, denoting the sound of the explosions given off by this gigantic grass when in flames.

Bandhuka.—[*Ixora coccinea*] "knotted," closely "compressed," referring to its compact terminal corymbs of bright scarlet flowers; the "Jungle Geranium" and "Flame of the Woods" of Anglo-Indians. Compare "Bandana pocket handkerchief." See Section E.

Dekamali.—[*Gardenia* sps:] "juicy," from the gum-resin exuding from the twigs of this plant. See Section E.

Karanj.—[*Pongamia glabra*] "water-reddening." See *pongam*.

Kavita, kuota.—[*Feronia stephantum*] "monkey-house."

Kino.—[*Pterocarpus marsupium*] "flesh"-coloured, from its gum: cf. "carnis"!

Maryadvel.—[*Ipomœa pes-capræ*] "boundary creeper," from its growing luxuriantly over sandy beeches along the littoral of the tropics of Cancer and Capricorn, and forming a broad, deep-green division between sea and land.

Moringa.—[*Moringa pterygosperma*] "perishable."

Muchakunda.—[*Pterospermum* sps:] "Jasmine-abandoned," i.e. Jasmine-covered.

Nag-kesava.—[*Mesua ferrea*] *nag*, "serpent," and *kesava*, "hairy" (the latter a name of Vishnu or Krishna, cf. *cæsaries*, and *Kæso*, and *Cæsar*), from its filamentous bright yellow anthers. For loveliness and fragrance one of the goodliest trees of "the Garden of God"; found growing about every Buddhist monastery in Burma; and sacred also among the Hindus, to their Cupid, Kama-deva.

Nag-phana.—[*Opuntia* sps:] "cobra-hood." *Opuntia* might be taken for the Latinised form of *phana*; but although these plants are natives of America, introduced into India by the Portuguese, their generic name, and the name of their natural Order, Cactaceæ, are both taken from the names of two plants—one found in the vicinity of Opus in Eastern Locris—known to the Greeks and Romans. They were probably cultivated thistles, like the artichoke.

Nyagrodha.—[*Ficus indica*] “growing downward,” the “Banyan” of Europeans, and so called by them, because, on first entering the Green Sea [Persian Gulf], they found one of these trees near Gombroon, the daily resort of the *banyas*, or native merchants, of Bombay. It is also called by the Hindus, *vata*, i.e., “the Tree” *par excellence*. See *pipala*.

Padma.—[*Nymphaea* sps:] “floating on the waters.”

Patali.—[*Bignonia suaveolens* and other species of *Bignonia*] “outspread,” “wide mouthed;” from their trumpet-shaped flowers. Compare *Patala*, the Hindu Hell, and *Patala*, the great “South Sea,” the Southern hemisphere, the Hades of the ancients.

Pipala.—[*Ficus religiosa*] “the Tree” *par excellence*. The *bodi-druma* (cf. *δρῦς*, *δρυμός*) or “wisdom-tree” of the Buddhists: *kalpa-druma* or “tree of the Ages” of the Hindus, who also call it *ashvata*, or “horse-stall,” from a legend that a sort of divinity lives in it, in the form of a horse.

Pongam.—[*Pongamia glabra*] “gold within,” from the colour of its pods when broken open. See *karang*.

Raktamba.—[*Garcinia indica*] “red mango.”

Ratalu, *ratarnvel*.—[*Ipomoea Batatas*] “red-potato” and “red-creeper” respectively.

Rohin.—[*Rottlera tinctoria*] “red.”

Rohitaka.—[*Amoora Rohitaka*] “red.”

Sag.—[*Tectona grandis*] “strong,” the Teak tree, so called from its Malabari name *tekka*, of the meaning of which I am ignorant. Its wood is the *σαγαλίνα* of Cosmas Indicopleustes.

Sagargota.—[*Guilandina Bonduc*, v. *Caesalpinia Bonducella*] “ocean pebble,” from its marble-like seed, the “Bonduc nuts” of commerce. *Bunduk* was the name given by the Arabs to filberts, because they first obtained them from Venice (*Banadik*). Then the name was transferred to these Indian seeds, and to the pellets shot from cross-bows, and finally to muskets.

Salai.—[*Boswellia serrata*] “exuding,” the Indian Frankincense tree.

Samudra sok.—[*Argyrea speciosa*] “sea-moan,” [cf: *Zamorin*]; this voluminous convolvulus, aptly called “Elephant creeper” by Anglo-Indians, growing throughout the coasts of Malabar and Coromandel in full view of the sea, the sad waves of which seem to be ever moaning among its tangled branches.

Sapta-parni.—[*Alstonia scholaris*] “seven-leaved,” from its leaves being in whorls of five to seven. This native name is often corrupted to *chatim*, *satwin*, and finally *Shaitan* (Satan)! This noble tree was a great favourite with the sages of ancient India, and the handled slate-like boards, called (cf. “horn books”) *pits*, used in Hindu schools, are cut from its wood, whence its specific botanical denomination.

Sirisha.—[*Acacia Lebbek*] “brittle.”

Soma-lata, *soma-vel*.—[*Calonyction roxburghii*, v. *Ipomoea bonanox*] “moon-creeper,” and so-called

also by Anglo-Indians, from its delightfully scented milk-white flowers, as wide across as large saucers, opening only at night. It is the “Lady of the Night” of the West Indies.

Svet-patri.—[*Mussaenda frondosa*] “white-leaved,” i.e., bracted. See Section E.

Tagara.—[*Tabernæmontana coronaria*] “brittle.” The unidentified ancient *Tagara* may have taken its name from this plant; and the closely-allied *karavira* (a word the meaning of which is unknown to me), *Nerium odorum*, or oleander, may also have given its name to *Karavira*, the ancient name of the kingdom of Kholapur. See J. F. Fleet's *Dynasties of the Canarese Districts of the Bombay Presidency*, 1882 pp. 4 and 98-106.

Tamara.—[*Nymphaea Lotus*] “copper-red,” the name of the red-flowered variety of this water-lily.

Tala, *tara*, *tad*.—[*Borassus flabelliformis*] “fixed,” the Palmyra tree. Toddy, i.e., *tari*, originally the fermented juice of this, and various other palms, better understood in the West as denoting that incomparable compound of whiskey with hot water, sweetened with sugar, which the congenial Scotch have now introduced to the utmost corners of the English-speaking world.

Udambara.—[*Ficus glomerata*] “sky-high.”

Uthphala.—[*Nymphaea stellata*] “up-springing,” “out-bursting,” the name of the blue-flowered variety of this water-lily.

Varuna.—[*Crateva religiosa*] “overshadowing,” cf. *οὐρανός*. Planted throughout India over the graves of the Mussulmans, and a beautiful object in the months of April and May, with its showy racemes of shining white flowers, cheering symbols of the Resurrection.

Vasuka.—[*Adhatoda Vasica*] “perfumed.” Its other Indian name, *adusa*, or *adulsa*, of the meaning of which I am ignorant, is obviously the source of its generic Latin name.

Wagati.—[*Wagatea spicata*] “tigerish;” from its wonderful spikes of scarlet and white flowers—

“Tiger! Tiger! burning bright
In the forests of the Night!”—

and large thorns.

Section B.—Names indicating the uses of plants.

1.—General.

Jambu, *jambul*.—[*Syzygium Jambolanum*] “toothsome,” “edible.”

Lakucha.—[*Artocarpus Lakucha*] “tasty,” “savoury.”

Mahwa, *mowra*.—[*Bassia latifolia*] “sweet.”

2.—Medicinal.

Bilva, *bela*, *bael*, *bil*.—[*Ægle Marmelos*] the perfect “cure.”

Kadamba.—[*Nauclea* sps.] “disease killer”; the holiest trees in India.

Nimba, *nim*.—[*Meila Azadirachta*] “healthful.”

Palasa.—[*Butea frondosa*] “active” in-gravel; gives its name to the fateful field of Plassey.

Section C.—Plant names of sinister significance.

Amba.—[*Mangifera indica*] “disease causing”; the Mango, so called by Anglo-Indians because first known to them by its Tamil name, *manka*, meaning “man-fruit.” The fruit is apt to act injuriously on the kidneys, and cows fed with its leaves for the production of the exquisite mango yellow dye of India, obtained from their urine, die in a few months.

Ganika.—[*Pisonia aculeata*] “harlot tree,” *cf.* γυνή, γυναικῆος, the “Lettuce-tree” of Anglo-Indians.

Ingalgunti.—[*Diospyros montana*] “scolding wife.” Spite of the divinity attaching to their generic Latin name, *Diospyros*, the ebony trees are all of evil omen in India, and Shakespeare’s [Hamlet] and Marlowe’s [Jew of Malta] juice of “cursed “Hebenen,” or “Hebon,” although actually a poisonous distillment from the yew tree, takes its feller characterisation from the purely mythical effects attributed to the juice of *D. Ebenum*, the “Heben” of Spenser, in the line from “The Vision of Petrarch”:—

“Made all of Heben and white Yvoric.”

Kakamari.—[*Anamirta Cocculus*] “crow-killer”; the “*Cocculus Indicus*” of commerce.” *Cocculus* is always said to be formed from *κόκκος*, but I feel sure that *kaka* is also in its etymology.

Mushti.—[*Strychnos Nux-Vomica*] “fatal.”

Tun.—[*Cedrela Toona*] “causing pain.”

Ummighilan.—[*Acacia arabica*] “mother,” or “haunt of devils.” See *babula*, Section A.

Section D.—Names expressive of the beauty and charm of plants, as also of their religious and poetical associations

Agni-shikha.—[*Gloriosa superba*] “flame-flower.”

Amlana.—[*Gomphrena globosa*] “unfading,” “amaranthine”; a native of America, but completely naturalised in India.

Aparajita.—[*Clitoria ternatea*] “unconquerable”; possibly referring to the superb “true blue” of its flowers, but more probably to its phallic power, as it is especially sacred to all the goddesses (*sakti*), and more particularly to the invincible Devi, the wife of Siva: *cf.* Aphrodite.

Arjuna.—[*Terminalia Arjuna*] “bright.”

Ashoka.—[*Jonesia Asoka*] “sans-souci.”

Bharya.—[*Dillenia spenosa*] “handsome.”

Bhor.—[*Zizyphus Jujuba*] “shining”; “the Jujube-tree,” allied to “the Lotus-tree,” identified with the mythical tree of Homer’s *Lotophagi*. “*Zizyphus*” and “*Jujuba*” are both progressive corruptions, through Greek, Latin, and French, of the Persian *zizafun*.

Chandana.—[*Santalum album*] “gladdening.”

Kamal.—[*Nelumbium speciosum*] “water adorning,” a name it bears in common with other water-lilies. “*Nelumbium*” is Latinised from the Cingalese *nelumbo*, “shining.” With the other water-lilies it is also called *padma*, “floating on water.”

Kanchana.—[*Banhinia sps.*] “shining.”

Madhavalata.—[*Hiptage Madablota*] “Spring (creeper) flower”; the “Delight of the Woods” of the drama of Sakontala.

Mandara.—[*Erythrina indica*] “beautifying;” also called *pangara*, identified with the mythical *parajita* tree stolen by Krishna from Indra’s heaven of Sverga. See *manjista* and *mudar*.

Manjista, mmmjit.—[*Rubia cordifolia*] “formosissima,” the “*Munjeet*” of commerce.

Mudar.—[*Calotropis gigantea*] “beautifying;” the same word as *mandara*, and cognate to *manjista*. Compare “*mundo*,” “*munditia*,” “*mundus*,” *κόσμος*.

Naklamata.—[*Pongamia glabra*] “night-shining.”

Phunus.—[*Artocarpus integrifolia*] “a pæan,” “praise,” its Canarese name: the Jack-tree of Anglo-Indians, so-called by them after its Malabari name, *jaka*, the meaning of which I do not know.

Sami-raja, sami, sumu, shimi.—[*Prosopis spici-gera*] “*Rex sacrificulus*,” the leading and cardinal sacrificial wood of the Brahmins. The others are *agara*, “fire chariot,” (?), *mudar*, *palasa*, *pipula*, *udambara* and *vata*; and the grasses, *dab* [*Cynodon Dactylon*], and *kusa* [*Poa cynosuroides*].

Shala, sal [*Shorea robusta*] “praised.”

Seventi.—[*Chrysanthemum indicum*] “sought after”; the “Seventee-bai,” represented as a daisy, of Miss Freres’ (in folk lore revival) epoch-marking *Old Deccan Days*.

Vana-raja [*Bauhinia racemosa*] “*Rex nemorensis*”; a title justified rather by its poetical associations than by its size, or its large but sparsely-blooming white flowers.

Section E.—Latin generic and specific names of plants of hidden Indian origin.

Confining ourselves to the names above noted, and omitting from these the generic name of *Zizyphus*, and the specific name of *Azadirachta*, both of which are Persian, and the specific names *Lotus* and *Lebbeke*, both of which are Egypto-Arabic, we have in *Pongamia*, *Moringa*, *Amoora*, *Tectona*, *Wagatea*, *Adhatoda*, *Mangifera*, and *Nelumbium*, generic names of obvious Indian origin; and in (*Adhatoda*) *Vasica*, (*Amoora*) *Rohitaka*, (*Syzygium*) *Jambolanum*, (*Artocarpus*) *Lakucha*, (*Nauclea*) *Cadumba*, (*Cedrela*) *Toona*, (*Terminalia*) *Arjuna*, (*Jonesia*) *Asoka*, and (*Hiptage*) *Madablota*, specific names, the Indian origin of which is equally clear. Among the above-noted generic names, *Santalum* also is undoubtedly the Latinised form of *chandana*, though the Persian *chandal*, and Greek *σάνδονον* and *σαντάλον*; and among the above-noted specific names I believe that (*Anamirta*) *Cocculus* must have *kaka*, “crow,” in its etymology; and possibly *kaka* is the prehistoric source of *κόκκος*! But there are several generic Latin names of plants, the Indian origin of which is so concealed that in one or two cases it has never been even suspected, and I believe I am the first to have given the suggested etymology of four of the following names:—

Carissa = Krishna; to whom, and Vishnu, the lovely Carissa Carundas, the *karunda* of the natives of India, is sacred.

Gardenia = *gandha-rajā*, "the perfume-king," the white flowers of *G. lucida*, and other species of Gardenia, being of a luscious and most exquisite fragrance, combining that of the orange flower, rose, and narcissus, and their stems yielding the strong odoriferous gum-resin *dekamali*. See Section A. The genus is usually said to have been named by Ellis in honour of Dr. Garden, of Charleston.

Ixora = *Eshwara*, or *Ishwara*—"god," meaning Siva. See *bandhuka*, Section A.

Pavetta = Parvati, "the Mountaineer," one of the names of Devi, "the Goddess," the wife of Siva. *P. indica* is the "wild coffee" of Bombay Anglo-Indians.

Quamoclit = *Kama-lata*, "Cupid's creeper," *Q. vulgaris*, "flos Cardinalis," "Jasmine rouge," the "Forget-me-not" of Anglo-Indians, being sacred to the Hindu god of love, Kama-deva; the crimson flowered variety being designated *lal-Kama-lata*, "the red ringlets of Cupid." The white-flowered variety is the *ishk-pecha*, or "Love's ringlets," of the Persians. Don, who formed the genus, derives its designation from *Kάματος* and *κλίτος*, and, if the far-fetched phallic allusion to be traced in this derivation was present to his mind, it might indicate that he was aware of the Indian and Persian erotic associations of the plant. The first person to suggest the true etymology of Quamoclit was John Graham, Deputy Postmaster-General of Bombay, the author of *A Catalogue of Plants Growing in Bombay*, 1879, the most alluring book on Indian botany ever printed. He died on the 28th of May, of the same year, at Khandalla, the favourite scene of his botanical explorations, and is there buried behind the Travellers' Bungalow, at the extremity, marked by his monument, of an upland turfy expanse, dotted all over, from June to September, with the white fragrant flowers of the little terrestrial orchid, *Habenaria platyphylla*.

Mussænda and Anamirta are generic Latinised names of plants above cited, which suggest Indian origins, but I can give no clue to them.

Section F.—Indian names of plants derived from names of places.

The Indian plants giving names to places are too many to enumerate; but two have been cited above—*tagara*, conjectured to have given its name to the ancient unidentified Tagara, and which actually gives its name to Tagarapuram in the Madras presidency—and *karavira* conjectured to have given its ancient name to the Kholapur state—and which gives its name to the modern village of Karavira in that state. The two following are the only native Indian names of plants derived from names of places.

Chamba, *champa*. — [*Michælia Champaka*], from Chamba, or Champa, a province of Cambogia, identified with Cochin-China by the early Arab

and European travellers (Marco Polo, Nicolo Conti, &c.) The country took its name from an Aryan tribe of the North-West Frontier of India, called Cambojas. Whenever they found their numbers increasing beyond the means of support to be found in the Tirah and Kurum highlands, they raided the rich lowlands of Hindustan, their raids at last extending into Farther India, where meeting with no more highly-civilised people than themselves, they permanently settled and gave their name to Cambogia; and to its best known vegetable production, gamboge. They also gave their name to Cambyes, whose family it has been recently said descended from the Cambojas. *Camb*, means "bent," "curved," "arched," and hence a "crest," the "neck of a horse," and again, the comb of a cock, and hence "strong," "brave," "warlike," and "truculent;" and it is interesting to note that Afridi, the same word as "Afrite" in the "Arabian Nights," is, in these latter senses, but a translation of *Camb*. This word *Camb* appears in Scotland in the form of Cambus, marking a "bend" in the Frith of Forth, in Cambus-kenneth, Cambus-lang, *et cetera*, and in Campbell, the clan of "crooked" mouths; and in England in Cambridge, the town of the "curved" ford of the Granta. There is really no river Cam, but only the Granta. The first name of the town was Granta-brycg, and the name of the Granta is still preserved in that of the village of Grantchester, near Cambridge. But the bridge at Cambridge marks the ancient Camboritum, *i.e.*, *cambo-rhed*, the "curved ford," the name of which becoming confused with Cantebriegge, the corrupted form of Grantabrycg, the latter gradually gave way to the mongrel form of Cambridge.

Yavanala.—[Zea Mays] "Ionian reed"; introduced into India by the Portuguese. From the time of Alexander's invasion the Hindus seem to have designated all Europeans as Yavanas, and still often speak, even of the English, when intending, apparently, to convey an intangible suggestion of contempt, as Yavanas.

GEORGE BIRDWOOD.

22 January, 1898.

DRY ROT.

Mr. Potter's most interesting paper on the "Fire-proof Construction of Domestic Buildings," reported in the last number of the Society's *Journal*, contains the remark, with reference to timber floors, that if they acquire dry rot the fungus which accompanies it is in a high degree dangerous to health. I have heard this statement frequently made in similar general terms before, but I have never been able to extract any reliable medical authority for it, and, as it is a matter which must affect the well-being of a very large number of householders, may I ask you to give publicity in your *Journal* to a request that some competent and qualified reader would be good enough

to record, for the benefit of the members of the Society, the ascertained results of the influence of dry rot on the health and well-being of those who are exposed to it?

E. A. HANKEY.

The Imperial Hotel,
Torquay, Devon,
January 31, 1898.

Notes on Books.

GLASS BLOWING AND WORKING. By Thomas Bolas, F.C.S. London: Dawbarn and Ward.

There do not seem to be very many English books on the subject of glass manufacture, and as regards glass-blowing on a small scale there are still fewer—in fact, the present writer cannot recall any except the useful little manual published by Mr. Shenstone in 1886. That work was intended solely for chemical and physical students. Mr. Bolas goes a little further and suggests that amateurs might amuse themselves by working in ornamental glass. The articles which can well be made with the appliances at an amateur's command are so small that probably the suggestion will not be very largely acted upon, but the idea may certainly be commended to those who have acquired any skill in ordinary glass-blowing. They will find it an excellent source of recreation and a valuable means of increasing their skill.

The book may be recommended alike to those who desire to acquire some knowledge of the art, but have never attempted even to blow a bulb on the end of a tube, and to skilled glass workers. The former class will find minute and complete instruction for the most elementary processes, and the latter will find many devices and suggestions of value to him in his work.

After an introductory chapter—mainly historical—Mr. Bolas begins by describing his apparatus, the blow-pipe and bellows, with the various simple tools and appliances, which are all the worker requires. They are all not only described, but instructions are given for their manufacture, or their construction from existing devices; as, for instance, when it is shown how two pairs of ordinary household bellows may be connected together, and converted into an apparatus for giving a continuous blast. Methods of working are then described, from the simple operations of bending or closing a tube, up to the more elaborate required in making a Sprengel pump, a thermometer, or an elaborate piece of decorated ware in coloured glass. A chapter or two on materials, and one on glass making at the blow-pipe and on a laboratory scale, complete the book.

THE BLASTING OF ROCK. By A. W. Daw and Z. W. Daw. Part I., "The Principles of Rock Blasting." London: E. and F. N. Spon. 1898.

This, the first part of the whole work, is published separately, the second part, which is announced as

dealing with appliances for drilling and methods of blasting, being in preparation. The subject seems to be treated very fully and comprehensively. Minute details are given on such points as the resistance in homogeneous rock, the form of cavity produced, the action of different explosives, the size, depth, arrangement, and position of bore holes, the effect of simultaneous and independent firing, the weight of charge required to shatter the rock and eject the rock after rupture, the influence of fissures and joints, and numerous other matters of importance to the practical worker. A number of formulæ are given, and tables to facilitate calculations.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock:—

FEBRUARY 9.—"Compensation to Workmen." By A. D. PROVAND, M.P. Major-General Sir OWEN TUDOR BURNES, G.C.I.E., K.C.S.I. (Chairman of Council), will preside.

FEBRUARY 16.—"The Protection of Industrial Property." By J. F. ISELIN, M.A., LL.M. Sir FREDERICK BRAMWELL, Bart., D.C.L., F.R.S., will preside.

FEBRUARY 23.—"Children's Sight." By R. BRUDENELL CARTER, F.R.C.S.

MARCH 2.—"Kites: their Theory and Practice." By Captain B. F. S. BADEN-POWELL.

MARCH 9.—"Linde's Method of Producing Extreme Cold and Liquefying Air." By Professor J. A. EWING, F.R.S.

MARCH 16.—"The Recent History of Paper-making." By CLAYTON BEADLE. Sir JOHN EVANS, K.C.B., D.C.L., F.R.S., will preside.

MARCH 23.—"The Preparation of Meat Extracts." By C. R. VALENTINE.

MARCH 30.—"Telegraphy Across Space." By Professor SILVANUS P. THOMPSON, F.R.S.

Dates to be hereafter announced:—

"Stage Mechanism." By EDWIN O. SACHS.

"Water Gas and its Appliances." By Professor VIVIAN LEWES.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock:—

FEBRUARY 17.—"The Plague in Bombay." By HERBERT MILLS BIRDWOOD, C.S.I., M.A., LL.D. (late Governor's Council, Bombay). The Right Hon. EARL SPENCER, K.G., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday Afternoons, at 4.30 o'clock:—

*** In consequence of the absence from England of Mr. Hamilton Merritt, the paper announced for February 15, on "The Goldfields of Klondyke and British Columbia," has unavoidably been postponed.

CANTOR LECTURES.

Monday Evenings, at Eight o'clock :—

CYRIL DAVENPORT, "Decorative Book-binding." Three Lectures.

LECTURE III.—FEBRUARY 7.—Decorative book-binding in England from the 16th to the 18th century—Gold and enamelled bindings made for Henry VIII. and Queen Elizabeth—Bindings embroidered on velvet of the Tudor period, and on satin during the 17th century—Gold tooled work by Thomas Berthelet in the 16th century, by Samuel Mearne in the 17th century, and by Roger Payne in the 18th century, and the influence of these great binders upon the art.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEB. 7 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Cyril Davenport, "Decorative Bookbinding." (Lecture III.)

Engineers, in the Theatre of the United Service Institution, Whitehall, S.W., 7½ p.m. Inaugural Address by the President, Mr. William Worby Beaumont.

Chemical Industry (London Section), Burlington-house, W., 8 p.m. 1. Mr. J. W. Lovibond, "The Curing of Malt in Relation to Colour and Value." 2. Mr. A. R. Ling, "Clerget's Method of Estimating Cane Sugar." 3. Messrs. A. R. Ling and J. T. Baker, "A New Modification of Clerget's Method of Estimating Cane Sugar, specially applicable to Molasses and After Products." 4. Dr. L. T. Thorne and E. H. Jeffers, "Note on the Estimation of Water in Invert Sugars."

Imperial Institute, South Kensington, 8½ p.m. Capt. S. Eardley Wilmot, "The Navy during the Queen's Reign."

Surveyors, 12, Great George-street, S.W., 8 p.m. Discussion on the paper read by Mr. A. A. Hudson, "Technical Tribunals and Surveyors as Arbitrators."

British Architects, 9, Conduit-street, W., 8 p.m. Mr. Edwin O. Sachs, "The Housing of the Drama: with special reference to Subscription and Endowed Theatres."

Camera Club, Charing-cross-road, W.C., 8¼ p.m. Rev. Walter Weston, "Japan."

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 8, Adelphi-terrace, W.C., 8 p.m. Paper on "The Egyptian Literature 18th Dynasty."

London Institution, Finsbury-circus, E.C., 5 p.m. Professor Vivian Lewes, "Incandescent Gas Lighting."

TUESDAY, FEB. 8...Royal Institution, Albemarle-street, W., 3 p.m. Professor E. Ray Lankester, "The Simplest Living Things." (Lecture IV.)

United Service Institution, Whitehall, S.W., 3 p.m. Mr. W. Allingham, "The Training of the Mercantile Marine."

Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Mr. William Thow, "The Security of Locomotive Fire-Boxes." 2. Mr. John A. F. Aspinall, "Friction of Locomotion Slide-Valves."

Photographic, 12, Hanover-square, W., 8 p.m. Annual Meeting.

Colonial Inst., Whitehall-rooms, Whitehall-place S.W., 8 p.m. Mr. H. Birchcough, "Some Aspects of Our Imperial Trade."

Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m. Asiatic, 22, Albemarle-street, W., 4 p.m.

WEDNESDAY, FEB. 9...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. A. D. Provand, "Compensation to Workmen."

Sanitary Institute, 74A, Margaret-street, W., 8 p.m. Prof. J. Lane Nottet, "Purification of Water for Barracks, Prisons, and other Institutions."

Royal Literary Fund, 7, Adelphi-terrace, W.C., 3 p.m.

United Service Institution, Whitehall, S.W., 3 p.m. Colonel J. D. Legard, "Army Organisation, with special Reference to the Infantry of the Line and Militia."

Royal Society of Literature, 20, Hanover-square, W., 1 p.m.

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on Major-General Webber's paper, "Notes on the Electro-Chemical Treatment of Ores containing the Precious Metals." 2.

Mr. Sherard Cowper-Coles, "An Electrolytic Process for the Manufacture of Parabolic Reflectors."

THURSDAY, FEB. 10...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 6 p.m.

Mr. Augustine Birrell, "Commercial Aspects of Fraud."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. C. E. Keyser, "Aldermaston Church, and its Monuments."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. J. P. Richter, "Some Italian Pictures at the National Gallery." (Lecture I.)

Mechanical Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on paper by Mr. Philip Dawson, "Mechanical Features of Electric Traction." 2. Prof. Frederic W. Burstall, "First Report to the Gas-Engine Research Committee: description of apparatus and methods, and preliminary results."

Mathematical, 22, Albemarle-street, W., 8 p.m.

Camera Club, Charing-cross-road, W.C., 8¼ p.m.

FRIDAY, FEB. 11...Royal Institution, Albemarle-street, 8 p.m.

Weekly Meeting. 9 p.m. Dr. J. H. Gladstone, "The Metals used by the Great Nations of Antiquity."

Civil Engineers, 25, Great George-street, S.W., 8 p.m. (Students' Meeting.) Mr. John T. Morris, "The Protection of Power Transmissions from Lightning."

Astronomical, Burlington-house, W., 3 p.m. Annual Meeting.

Philological, University College, W.C., 8 p.m.

Clinical, 20, Hanover-square, W., 8½ p.m.

Physical, Chemical Society's Rooms, Burlington-house, W., 5 p.m. Annual General Meeting. 1. Address by the President. 2. Mr. G. H. Bryan, "Electromagnetic Induction in Plane, Cylindrical, and Spherical Current Sheets, and its Representation by Moving Trails of Images."

Mechanical Engineers, 25, Great George-street, S.W., 8 p.m. Mr. Sidney Tebbutt, "Steam Laundry Machinery."

SATURDAY, FEB. 12...Botanical, Inner Circle, Regent's-park, N.W., 3¼ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Mr. W. Hadow, "The Structure of Instrumental Music." (Lecture I.)

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FRIDAY, FEBRUARY 11, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.

CANTOR LECTURES.

Mr. CYRIL DAVENPORT delivered the third and last lecture of his course on "Decorative Bookbinding," on Monday evening, 7th inst., when he dealt with English bindings in enamel, velvet, embroidery, and leather.

The CHAIRMAN (Mr. Lewis F. Day) proposed a vote of thanks (which was carried unanimously) to Mr. Davenport for his valuable lectures, and for the specially fine series of coloured lantern slides with which they were illustrated.

The lectures will be published in the *Journal* during the summer recess.

FOREIGN & COLONIAL SECTION.

The meeting on Tuesday, February 15th, will not be held in consequence of Mr. Hamilton Merritt's absence from England. The paper on "The Goldfields of Klondike and British Columbia," which was announced to be read on that day by Mr. Merritt, has unavoidably been postponed.

Proceedings of the Society.

APPLIED ART SECTION.

Tuesday, January 25, 1898; WILLIAM LUSON THOMAS, R.I., Member of Council, in the chair.

The paper read was—

RENAISSANCE WOODWORK IN ENGLAND.

By J. HUNGERFORD POLLEN.

In the following remarks I do not intend to touch on the matter of furniture—a subject on

which I have been loquacious before. I want to discuss woodwork, and of the Renaissance kind, from the point of view of the architect. Both in the construction of buildings and in adaptation to human occupation wood plays an important part. From the days of Greek temples, so moderate in size as compared with the imposing structures of Imperial Rome, timber has been a necessity. Special and exceptional buildings only could dispense with it; and if wood is necessary in hot climates it is much more indispensable in the north. The vast churches, halls, and palaces of civilised Europe require timber of large growth to support roofs which are of high pitch (in climates liable to heavy snow falls), and even when the art of vaulting great widths came into use, these vaults also required a timber roof over them.

Then the insides of our northern buildings require some sort of lining to cover over stone and brickwork. The Greeks had white marble at their doors. The Romans had ships and soldiers, and could help themselves to the precious building materials of the countries bordering the Mediterranean. Hence it was no serious difficulty for a Roman Emperor, who found Rome a city of brick, to cover that material with a coating of marble. In Rome, as in Greece, the interior of the house was the place for *coolness*, rather than warmth, therefore marble walls were refreshing, like marble seats and benches; and where marble was out of reach the Romans lined their walls with stucco and painted it.

We, on the other hand, have no need to look for cold air. There is plenty of it out of doors. We don't care to feel icy walls of brick or free-stone. We prefer panels and benches of wood. If not with wood, then, as so extensively in the Middle Ages, walls were covered with tapestry, or the substitutes for tapestry, silk, and so down to paper. Wood, then, is a necessary quantity in estimates for building, and to use it either constructively or decoratively is an important necessary accomplishment of the architect.

Wood in the Middle Ages and, indeed, long after, was the material of which houses and entire cities were built. London, down to the time of the Great Fire was a timber city. Interspersed with palaces, churches, of course, and castles of solid stone, but as a city with congeries of streets, lanes, alleys, &c., it was a timber city, and once on fire it blazed as timber streets would. The art of woodwork was therefore well understood and widely prac-

tised at the time in which the Renaissance took place.

As to the word "Renaissance," I need hardly remind you, because everyone is familiar with it, that renaissance, or new birth, means the new birth or revival of the classic learning, the works of the ancient Greek and Latin writers, and the interest in the ancient temples and sculptures of the Greeks and Romans, which these writings excited. Then, again, at the close of the 15th century, the Roman Pontiffs had returned to Rome after long absence. There, as in Florence and other Italian States, these remains of classic art interested and captivated the Italians of the later 15th and the whole of the 16th century. It was not a new religion, but the enthusiasm it created was as great as if it had come down from heaven in the brain of some celestial messenger. Old Greek and Roman names, Alexander, Hercules, Horace, and numerous others, were assumed or given. We hear of a Sir Julius Cæsar in these sober islands. In short there was no standing out against such a mighty rush. Our particular subject, the art of woodwork, became Renaissance woodwork, and as such it remains in possession to the present day. Yes, even something of it survives in the jerry builders' roofs and partitions; much more in the roofs and stages of our great public halls and theatres.

As applied, indeed, to woodwork, the Renaissance affected the ornamentation rather than the construction of woodwork, and though it is called a new birth, it came to maturity very gradually in countries our side of the Alps.

1. In England the Renaissance art must be credited to Henry VII. His accession marked a new era, not in the arts alone, but in politics and manners. The feudal system came to an end at the battle of Bosworth, and the king was absolute.

As regards the new architecture, Henry did little beyond erecting the splendid tomb made for him by Torrigiano, the Italian sculptor, now in Westminster Abbey. He built churches, though he was not fond of spending his money. But his churches were in the pointed architecture still in fashion in his day, and we may refer to an example in his chapel at Westminster. Though it is in a debased phase, it still belongs to the English late pointed style. It is admirably constructed, and we recognise in it the work of a race of builders perfectly familiar with the system of vaulting, the weight and size of buttresses necessary to support it, and complete familiarity with their materials.

The most successful decoration of the chapel lies precisely in its woodwork, which shows no special character of Italian renaissance, but which does show the hands of skilful constructors and carvers. The light and free fretwork of the stall canopies, and the admirable groups and figures in the round, carved under the *misereres*, may be compared with any mediæval stall carvings, showing what an excellent school of figure and ornamental detail carvers the country then possessed. As regards skill in wood construction we have proof in the adjoining roof of Westminster Hall, erected some two hundred years before. I conclude that all the present company are familiar with it. The truss or framed structure in ordinary roofs which throws a bridge across from wall to wall, is replaced at Westminster by a collar beam about a third of the length of the rafters, supported by a great cusped arch of timber, that brings the weight of the roof half-way down the walls. Rows of small mullions with cusped arch-heads fill up the spandrils between these curved braces and the beams which they support, and complete the splendours of the construction.

Such were the structural and decorative attainments which the Renaissance woodwork was to replace. But, as we shall see, these old principles died hard.

The Renaissance art and architecture was introduced by the Tudor princes—gradually, no doubt. Guilds of carpenters, joiners, and carvers, under whom the workmen of the day had been educated, did not, and could not easily unlearn a kind of art which they could put into execution by a sort of instinct. The elaborate drawings of modern architecture were then neither provided nor required. A guild-master could set his men to work, when measurements were settled. Small deviations, which do not affect the apparent correctness of measures, or of details that balance each other, were overlooked or uncared for. Any examination of ranges of carved panelling, for instance, will show here and there such deviations. Little details in carving, such as small animals, birds, &c., are frequently found inserted to amuse the carver as he proceeded.

But these mediæval guilds survived only to the reign of Henry VIII., who seized their property.

Henry VIII. was not a builder of churches, just the contrary, he destroyed them on a large scale, and in a most barbaric fashion. But he was a builder of houses. As he was a

man of considerable personal accomplishments and well provided with money, his houses were splendid. The first and greatest of the artists he entertained was Hans Holbein, a Swiss, an accomplished draughtsman and painter, and an admirable designer, not only of portraits as the "Court Painter," but of goldsmiths' work and woodwork.

There is an elaborate drawing of a dagger-hilt and sheath by him in the British Museum, and another of a gateway from Whitehall into St. James's-park, decorated with elaborate woodwork. Where the drawing is I am uncertain; perhaps in the Library of Windsor Castle. Henry built for one of his queens a residence in Surrey, known as "Nonsuch," that is "unequaled." Judging from a representation in the background of a picture, it must have been mainly constructed of wood, and splendidly carved.

There is in the Priory House in Reigate a carved oak fireplace, formerly in "Nonsuch," but turned out of it after the Civil Wars, when "Nonsuch" was ruined or much injured. The fireplace has a circular seat on each side, each seat covered by a canopy of tabernacle work, the details of which—columns, triumphal arches, little figures of genii, all on a minute scale and of a classic character—are carved with astonishing delicacy and finish, *e.g.*, Corinthian columns 9 or 10 inches high (I speak from memory) are fluted, the capitals perfect in detail; each little genius, 4 or 5 inches high, correspondingly perfect; from seat to seat stretches a complicated trellis cut out of the solid, the bars of it *shown in perspective*, and a Tudor rose bush twining in and out. Above, two flying genii support the Royal Arms, sculptured to perfection.

Whether this fireplace is the work or design of Holbein, we have no documents, as far as I know, to prove. It is his in character, and probably all the carved decoration of the place was from his drawings. Henry, like most of his royal contemporaries, liked to entertain such artists as could manage the masques, pageants and sports of their courts. Some of these required costly contrivances, shifting scenery and transformations, like those of our pantomimes. Such artists could also design dress, jewellery and furniture. Architecture they took to when required. It must be remembered that master builders of the 16th and 17th centuries were familiar with the details of mere building from long-known traditions, and in this respect were far in advance of professional builders of our day.

Of Holbein's architectural style there are examples at Hampton Court, and at Wilton-house, near Salisbury. As to panelling, so important an element in the finish of houses and churches, there is at Hampton Court a painting by Holbein representing the king seated with his family about him; and the chamber is panelled with elaborately drawn and gilded scroll work in each panel. Whether the painter painted from work actually existing or not we cannot say, but, seeing the splendour of such details of interior decoration as are still to be seen at Hampton Court, it is probable that he did. This is the more likely as the panelling in the picture is the back of a throne or State seat.

Henry had Girolamo da Trevigi also in his service, but no special work, as far as I know, is credited to him.

Another artist settled by his invitation in England was John of Padua, architect, but also an accomplished musician, in which capacity he seems to have served his majesty. Very little is, at present, known of John, nor whether he hailed exactly from Padua or, as some say, from Venice. He built several of the more sumptuous country-houses still existing. Longleat, in Wilts., is one. Wollaton, in Nottinghamshire, is sometimes attributed to John of Padua, but, I believe, more properly to John Thorpe.

2. John Thorpe belongs to the last quarter of the 16th century, and we know more of his work. Wollaton has been mentioned. Holland-house, in Kensington, and Burghley-house, near Stamford, are of his design. A book of his studies is preserved in Sir John Soane's Museum, Lincoln's-inn-fields. Several other houses might be mentioned. He does not seem to have built timber houses nor, if we may judge from Wollaton, to have cared for decorative woodwork. The large houses built during the reign of Elizabeth have been, in many instances, only partially brought to completion internally by the original projectors. The woodwork is, therefore, often later in date and in style than the exterior, and some of the best panelling of the time may be seen in Sizergh Castle and at Haddon-hall. Both these houses are old mediæval strongholds, with additions built at various times. In Sizergh the large drawing-room is beautifully panelled in small squares, the centre raised, and with delicate lines of moulding worked on it, in addition to the small moulded lines of rails and stiles.

Besides carving, the Elizabethan period pro-

duced a different kind of woodwork decoration, a fine example of which has been removed from Sizergh Castle to the South Kensington Museum. The entire interior of the room is of inlaid work in various patterns of arabesque ornament. The divisions of the walls, the skirting, dado, and cornice are treated with special running borders, and lengthwise the walls are divided by pilaster-shaped panels. The woods which are used for inlaying are black bog oak and white wood of some kind, probably holly. Lime or poplar are probably also to be found in this ornamentation. The ceiling, in South Kensington, is a reproduction from squeezes of the original, still *in situ* at Sizergh.

One other example of Elizabethan woodwork I will show presently on a lantern slide. It is from Kenilworth, the palace of Elizabeth's favourite, Robert Dudley. The ceiling of the room is of oak divided into large squares by mouldings, and the fireplace is surmounted by an heraldic scutcheon displaying the Royal arms and mantling.

The reigns both of Henry and Elizabeth saw the founding of new families, and the heads were accomplished men, and built up their fortunes and their houses with much skill and corresponding magnificence.

So far, then, as to the style of woodwork properly called Elizabethan. It is, however, difficult even when the name of the architect is known, and the date of the house, to be sure of the date of interiors as we now see them. I shall have to point presently to structures almost mediæval in character belonging to times later than Elizabethan, while much of the Holbein period is more decidedly Renaissance than anything we find in the reign of Elizabeth. Usually a new style in architecture comes in gradually and reaches completion after a lapse of years. But the Tudors were violent rulers, and imposed their will and their fashions in house decoration, as in much more serious matters, tyrannically. Still, notwithstanding these influences, the old ideas of the nation—the memories of the splendid England of the 14th century—died hard, and when the last Tudor was buried, popular taste reverted in the direction of mediævalism. The Elizabethan of the 17th century is that which is seen in the large majority of our halls, manors, abbeys, and houses called by these and other names, and this mixed style is more genuinely English, and continues more popular, than the classic style of Inigo Jones and Wren, which belongs to the time of the later Stuart kings, and is of a confirmed academic character.

3. The most imposing features of the houses of the 17th century are the great halls with their massive tables and benches, in which the hospitalities of the owners were dispensed, and masks, pageants, and dances prepared for the entertainment of the neighbours. The halls generally rise through the first floor, and communication across them on that floor is secured by a gallery, closed with lattices or concealed by the upper ornaments of the great screens of carved oak which divide the hall from outer entrances, and from the offices. The fires were no longer made in the middle of the room, as at Westminster School, at Penshurst, and a few other places, but in large fireplaces with imposing fronts carved with armorial bearings and other decorations. Telamons, human figures serving as piers or brackets, are favourite subjects; burly and massive figures, boldly and spiritedly carved, look down upon you from these structures and seem to welcome the traveller to their abode; family portraits (sometimes bad enough) cover parts of the walls.

Family trophies, regimental colours, arms that have belonged to sons and ancestors long dead adorn these walls, to say nothing of notable stag horns, rare birds, stuffed phenomenal fish caught on the property, and the like. The halls represent the families that have lived and died in the old homes. New men who build or buy such places in our day are said to buy rows of sham ancestors and trophies of arms arranged in stars to replace genuine relics of this kind.

Next to screens and fireplaces we may name the roofs. Many halls—those of Hampton Court, and of Christ Church, Oxford, for example—are roofed in the old, mediæval manner; less gracefully put together, and with the decorated parts heavier and loaded. Still these roofs are the old mediæval roof revived, and are dignified and impressive structures. I doubt whether in the 17th century any country except our own retained them.

The panelling of walls was simple, but in many cases retained the old "linen" pattern, perpendicular mouldings representing napkins folded in plaits. Some of the panelling in the South Kensington Museum is set off by carved pilasters and by a frieze carved with figures of the seasons or genii, &c. But the size of the panels is ruled by the average width of the planks of heart wood from which they are cut.

The building of these roomy country "mansions" continued till the time of the Civil War.

It was from the owners, with their servants and tenants, that the Royal armies were recruited.

4. It is time now to turn to an architect who did much to bring what I have called the academic renaissance into fashion, and renaissance woodwork into line with it. I do not call the early changes introduced by Henry and Elizabeth, the early modest adoption of Corinthian columns and other antique ornamental detail, academic. It did not take its origin from written rules, mechanically worked out in treatises and books, but by following living men who had been trained in older traditions, and superadding to them what impressed them in the old temples, triumphal arches, and ruined palaces of Rome. They introduce sculptured children and animals into their work, always with a right feeling of "propriety," the *to prepon*, the really "becoming." The later renaissance was the product of learned men who had analysed the huge temples and ruins of Italy and reduced them to rules, as academies of art in our day manufacture artists by rules. Rules are good as tests required to measure and test the work of a painter or an architect, but they will not make either. *Poeta nascitur non fit.*

Inigo Jones, whose work was of the complete full blown classic kind, was himself an artist of great power. He was born in 1573, and, as some say, was apprenticed to a joiner. At an early age he travelled to Venice and other places. Built a palace at Leghorn, and another for the King of Denmark, and bought sculpture and other works of art for the Earls of Pembroke, Arundel, and Danvers. He flourished during the reigns of James I., and Charles I. His great design was for a new Royal Whitehall, the old palace of Wolsey having been burnt in 1618. All that was built by Jones was the banqueting house opposite the Horse Guards. More than one set of designs for the entire palace remain and have been engraved.

Jones became attached to the Court of James I., some time before 1610 as the inventor and contriver of masks, scenery, and general designer for the Court. There is a King's Thames barge at South Kensington, possibly of his design. He seems to have been a devoted admirer and follower of Palladio. All his architecture is simple and massive. Wilton-house, Salisbury; Ashburnham-house, Westminster; Brympton, Somerset (the front), and many other houses are existing examples. His woodwork is suited to the massive character of

his exteriors. I have lantern slides of some of his panelling which has more design in it than that of Wren, who came after him. His inventiveness, as his Majesty's contriver, was of service to his woodwork. Shifting scenes, of which he had learned the art in Italy, are said to have been introduced into this country by him. His more important fireplace fronts were of marble, but a large number of them were of wood, the composition and ornamentation being similar in design to his marble ones. There are certain decorative features very frequently seen on these objects; for instance, groups of three long acanthus buds, looking rather like three fishes, which have seemed to me a sort of Jones signature, whether invented by him or borrowed from Italy.

Another favourite moulding of Jones's is the square fret, and another the curve rolling over like the waves of the sea, called the Vitruvian roll; and another of his decorations in wood is the swag or hanging garland. We find this last on fireplace mouldings and at the flanks of picture frames where, in either instance, the angles break out, commonly called Vandyck frames, because often used for Vandyck portraits. Jones used Telamon figures, *i.e.*, figures as members or apparent members of support, in his chimney fronts. This kind of carving became a fashion, sometimes facing the spectator, sometimes sideways in profile. Later architects, Kent and others, made use of these various decorative features in the woodwork of London houses. Examples from Wood-street, and the demolitions of Carey-street, &c., may be seen in the South Kensington Museum and in furniture shops.

Altogether it must be acknowledged that Jones, if he did much (as I think he did) to academicise renaissance interiors as well as exteriors, he did it with a certain nobility, and that in the woodwork interest he stamped a lasting impression on his country.

5. Next to Inigo Jones we must rank Sir Christopher Wren, an admirable constructor, and not wanting in the capacity of decorative composition in his architecture. He is said never to have travelled beyond the four seas, and that this fact was a professional disadvantage. I do not altogether admit that latter view. He might have lost as much as he would have gained by the variety of fashions he would have seen in Italy and France.

Wren's woodwork may be seen in the stall work of St. Paul's Cathedral and some collegiate chapels. There are details at South

Kensington from the old stalls at Eton College. His stalls are covered by a continuous flat roof or shelf supported by brackets beautifully carved with acanthus in graceful rolls. His panelling in parish churches can be seen in London City churches. Many of them were re-built by Wren after the Great Fire.

For house interiors he may be well studied in Greenwich and Hampton Court. His paneling is on a large scale, a set of dado panels below, and of tall panels 8, 9 or more feet by about 3. The mouldings are large in proportion. At Hampton Court, occasional swags of Grinling Gibbons carving in lime wood are introduced. These interior fittings are quiet, dignified, more "proper" than interesting. The windows of Hampton Court are of the Dutch kind, tall sash windows; useful, but wanting in any kind of decorative effect. Wren had many imitators. His architecture, under other hands, devoid of the decorative capacities of Wren, has resulted in the dullest of the streets and squares of Georgian London. Wren panels, staircase balustrades, &c., survive in hundreds of the houses built after his death.

6. Next we must notice Sir William Chambers, an architect of the middle of the century. He did travel in many countries, and brought back his Chinese notions, which he carried out in woodwork: Chinese summer-houses and garden trellises which he had carved among the ornament of woodwork, looking-glass frames, &c. His treatise on "Civil Architecture" is of value in so far as it is academic in character. It describes the details of classic woodwork ornamentation—dadoes, bases, wall divisions, and the different members of entablatures, with some explanation of the typical meaning of classic mouldings. His frets and trellises, of Chinese origin, are worth studying and remembering. There are rooms in old houses of 150 years ago papered with the admirable wall papers of the China of the days in which these borders of trellises and fretwork are effectively employed. Sir William built the present Somerset House. He found the old rooms, part of the dower house of Queen Henrietta Maria, furnished completely, just as she had left them.

7. The last master of internal woodwork decoration whom I will notice is Adam, or, rather, the two brothers, Robert and James, for they seem to have practised as partners. We are

assembled this evening in one of their houses, built over what was once Durham-yard, part of the premises of the Bishop of Durham's London house. The Adam houses are all round us here. Certain features are observable on their exteriors—oval medallions, pilasters, covered with rolling scrolls in relief. Old Northumberland-house at Charing Cross, now destroyed, Sion-house, several Portland-place houses, Lansdown-house, and others, are or were good illustrations of Adam ornamentation in wood and plaster. His mouldings are delicate, sharply cut, somewhat wiry and dry and cramped when compared with the flowing lines of Wren's woodcarving; still, not without refinement and distinction. The Adams undertook the entire direction of the houses they erected, and of the furniture suited to them. This may be seen in their published views of the interiors of Sion-house, Derby-house, and others. They seem to have employed Sheraton and his imitators largely for their furniture designs.

Here I will bring these remarks to a conclusion. I have noticed what I call the academic system of architectural decoration in wood as in stone. I think the rules which academic writers have been able to deduce are of great value as tests to be resorted to as builders test their work by the application of the level. But rules do not create artists. Artists who do not understand this: tradesmen architects, jerry-builders, who compose from books, and are confident that they are right because they find things in books, are often the vulgarest as well as the dullest of performers. Real artists from time to time violate laws, but know how far they can do so, not only safely, but in obedience to a higher rule, an idea born in their own minds, which academic rules impede rather than subserve, and which owes its successful treatment to the artist's perception of what is conducive to his object. Hence it is that the incongruities discernible in the mixed Renaissance and Mediæval woodwork have often a more entirely decorative propriety than the cold and lifeless exhibitions of academic correctness.

Neither the figure carving nor the scroll work of these 17th century English carvers can compare with Italian sculpture, if we refer it to the work of the purest periods, or to that of famous artists. But famous artists are very rare creatures, and carvers who can do no more than copy and attain neatness and a smooth surface, may be in some sense correct, but racy or interesting never.

DISCUSSION.

Mr. C. PURDON-CLARKE, C.I.E., said he had not come prepared to say anything, but was rather inspired to do so by Mr. Pollen's paper and the beautiful illustrations. Those pictures of interiors in Nash's drawings showed how necessary it was for the modern designer to study completely and attempt to emulate that remarkable period of art in England. One of the remarks in the paper raising the question whether Wren lost by not going abroad, was almost met by the fact that it was only the work of the men whose education was almost entirely foreign that was cold and lifeless, but when native talent came forward and adapted the new style, that we began to get something worth looking at. It was perhaps unfair to compare Nash's artistic drawings with the other illustrations from books—simply geometrical elevations of Jones's and Wren's work. But their stiff, classical interiors, drawn in perspective were quite wanting in the interest possessed by the works of almost unknown men drawn by Nash. There was something in the latter which appealed to one in the perfect freedom with which the architect claimed to subordinate the details of the style to the requirements of the house or room he was designing. No two were exactly alike. Take Speke Hall or Haddon, or the long rooms at Knole—in every case you felt that the designer was doing his best with the artistic material, and though you could see by the plans that it was often tinkering an old building, he produced the most beautiful result, where the more scholarly interiors, four square and solemn, gave the feeling that it was a lifeless copy of some palatial building or temple. Within the last few years more attention had been paid to this English renaissance, and he was glad to say that at South Kensington Museum they had rescued and preserved many pieces which were in danger of being lost. The room at Sizargh, if it had not been secured for the Museum at what was considered a very large price, would have gone to America; a grievous loss as it was almost the only example of its kind in England. They had also a room from Exeter, of which some details had been shown, which was bought many years ago, and was now being erected in the Museum where it would soon be on view.

Sir GEORGE BIRDWOOD said—They had to thank Mr. Hungerford Pollen for a most instructive and interesting paper, treated with the comprehensiveness, thoroughness, and ease which came of the familiarity of a lifetime with its subject. One point brought out in the paper, which it was particularly desirable to emphasise at a time when there was so much ignorant and mischievous jealousy of foreign competition, was our great indebtedness to foreign influences for the noble national style of domestic architecture and woodwork developed in this country during the Renaissance. We were under great obligation to the influence of foreigners in the initial

stage of nearly all our national arts, such as painting, goldsmiths' and silversmiths' work, and jewelry, and the great decline in the arts of this country from about 1820, to the adoption of Sir Robert Peel's policy of Free Trade in 1846, is directly traceable to our isolation from the influence of foreign precept and example during the protracted period of the great Napoleonic wars. He cordially agreed with Mr. Hungerford Pollen's opinion that the details of the internal decoration of a house should be designed and carried out by its architect. He had himself always advocated this course being followed, and so far as he was able, had not allowed his advice to remain a mere "counsel of perfection." The effect was always good, as in the case—to take a recent example—of the Imperial Institute, where not only the panelling of the rooms, but the chimney pieces, and grates, and fenders, and fire-irons, and some of the coal-scuttles, were all designed by its distinguished architect, Mr. Thomas Colcutt. But the architect ought also to be asked to design the principal chairs and tables of the houses built by him, and the carpets and window hangings. Seeing also how much Nash's illustrations of our old country houses were set off by the costumes of the people living in them, one could wish that the clothes of contemporary English ladies and gentlemen were designed by scholarly artists, instead of being left to the caprices of ignorant, and often vulgar, "leaders of fashion." If he might offer a criticism, it was to say that he was not accustomed to hear Inigo Jones spoken of as "Jones." It grated on his ear, and he would respectfully hope that in the paper as published, the name would be printed Inigo Jones. But he was not there to criticise, but simply to express his, and their, gratitude to Mr. Hungerford Pollen for the delightful paper with which he had favoured them. No one was more esteemed by his old colleagues at "South Kensington" for the fulness and accuracy of his learning in art, or more revered for the graces of his character, than Mr. John Hungerford Pollen. A friend of the illustrious Cardinal Newman, he took a leading part in the artistic revival which rapidly followed on the religious revival of a generation ago at Oxford; and much of the beautiful painting at Merton College is by his "prentice hand." In recent years he has been intimately associated with the internal decorations of the Brompton Oratory. He is the author also of several of the most valuable and attractive of the handbooks on industrial art published by the Science and Art Department, and the distinctive note of all the work of his hands, whether artistic or literary, is the impression they convey of the author's profound and vivifying conviction of the sacramentality of art in all, even the humblest, of its applied departments. Mr. Pollen always reminds him of Theophilus, the monk, who in his book on the industrial arts recommends the study of them as a recompense of heavenly praise: *retributionem celestis premii*; and asks those who may find pleasure and profit from his book to pray for

the pity on him of Almighty God, who knew that he had written the things to be found therein not for the praise of men, nor for any worldly gain, but for the greater glory of Him, in whose Divine counsels and genius every artist was a participator: consilii ingenique participium. The latter thought is expressed in the *Book of Wisdom*, ch. ix. 8-10:—"A temple upon the Holy Mount, and an altar in the city wherein Thou dwellest, in the similitude of the Holy Tabernacle which Thou hast prepared from the beginning, and Wisdom was with Thee. Oh send Her out of Thy Holy Heaven, and from the throne of Thy Glory, that being present, she may labour with me." Again, we read in *Exodus*, xxxi., 2-6, of the master-craftsmen Bezaleel and Aholiab:—"And I have filled them with the Spirit of God, in wisdom, and in understanding, and in knowledge, to devise cunning works in gold, and in silver, and in brass, and in cutting of stones for setting, and in carving of wood in all manner of workmanship." This consecration of Art is its noblest inspiration and glory; and every artist so inspired exults in the perfection of his work, without taint of human vanity—as possessed in itself of something of divineness—after the manner of the builder of the beautiful chapter-house at York Cathedral in the inscription sculptured on its doorway:—"Ut Rosa est Phlos phlorum sic est Domus ista domorum." This is the spirit in which Mr. Hungerford Pollen has always laboured. You do not discover it from anything he ever says about himself, but it reveals itself in all his work; and the recognition of its presence is what has won for him the love and admiration of his old associates, and is what, for me at least, constitutes the highest charm of his paper to-night.

MR. I. HUNTER DONALDSON said it was a great consolation to know that there were two English architects who prided themselves on never having been abroad, and who had produced very large, and in many respects, admirable works; but of course they had in their libraries all the books which treated on foreign works and had practically the advantages derived from the study of what had gone before. Still, from his acquaintance with foreign work, he could not help thinking that they had lost much by not seeing the actual buildings themselves and comparing one with another. He thought it must have struck anyone who had given much thought to the matter, how the Brothers Adam had managed to permeate all England with the feeling of love for the art they illustrated. They were particularly fortunate in having such persons as Angelina Kauffmann Flaxman, and others associated with them, but it seemed almost unaccountable how they could have managed to inspire educated English people with a love for the work in which they so greatly excelled. In that part of London they were particularly fortunate in having so many beautiful examples of their work, and anyone who studied them would feel that

they had a very refining and valuable influence. He did not think it was possible to point to any one work produced by these men which could be termed ugly. An element of grace and beauty, a distinction and refinement, seemed to pervade all they produced. Turning to the works which preceded them, he felt how much they owed to Mr. Pollen for what he had brought before them, and the mystery to him was that in England, with so many opportunities of knowing what was beautiful and graceful in ornament it was possible for such ugliness to obtain in architecture, and that there were so many structures still to be found in London deteriorating the public taste and altogether offensive to a refined eye. In some respects it resulted from the want of proper training of architects and those interested in art in this country. He did not think the English people felt the importance to anything like the same degree as the French of knowing the details relating to each particular style. Take the Louis XVI., or any other style, you found a foreign workman or artist associated with it was a thorough master in its particulars and detail relative to it. It had been thought sufficient in this country that a man should draw with more or less facility, but they had not been sufficiently purists, and thus they had disfigured the country with buildings and all kinds of things, showing a want of harmony and of the distinguished charm which prevailed in all the work of the Brothers Adam. It was a matter of great regret that sufficient attention was not paid in schools of arts to that purity of style which obtained amongst the French. If you spoke to a French manufacturer engaged in the production of silver, brass, or woodwork, you found him thoroughly acquainted with all the details of the style with which he was known to be connected. If you went into any particular room, you found it was carried through with one idea that suggested one style, and there was a harmony and unity throughout. He hoped, however, that in time England would come to be as distinguished for its adherence to unity in style as France.

SIR GEORGE BIRDWOOD said he could not agree that all the houses in their neighbourhood, by the Brothers Adam, were beautiful. Their interiors, he recognised, were, for the most part, perfect, but some of the exteriors were not, in his opinion, worthy of these eminent architects. They were overloaded with decoration—decoration which did not grow organically out of, and merely emphasize the construction but overpowered and largely obliterated it, as if it was but a peg on which to hang the decoration; and, in consequence, the fronts of some of the houses in Adam-street present an ostentatious aspect, to which no familiarity can reconcile the eye.

MR. H. B. WHEATLEY said it had been supposed by some that John of Padua and John Thorpe were the same man. Very few particulars of their lives

were known, and he would ask Mr. Pollen for his opinion on that point. With regard to the Holbein gateway at Whitehall, it was built and remained till 1759 across the public road close by the Banqueting House; it had been often depicted in topographical works. With regard to the plaster decorations in the work of the Brothers Adam, he thought it should be borne in mind that, though it was exceedingly good for the interior, it was often weak for the exterior. These architects did not seem to have realised that treatment which was suitable for the inside of a house was not suited for the outside. An illustration might be found in that very room. The ornamentation of the frieze there was very appropriate, but the same ornamentation was used on the outside of some of the Adelphi houses, and, of course, in a smoky place like London you require the ornament outside to be more prominent and not so slightly raised on the surface as was quite suitable for the inside of a room. He hoped, therefore, that the work of Inigo Jones would be followed in the future rather than that of the Adams. It was a great pity, seeing how much Inigo Jones did for the architecture of London, that his work should be so much neglected. There were in Great Queen-street two of the finest bits of street architecture in London; and on the west side of Lincoln's-inn-fields there were a number of houses with the original red brick pilasters which he built. Unfortunately, many of them had been plastered over and spoiled, but they still existed and were in the very best style of street architecture. He hoped that, in the re-building of the streets of London, the work of Inigo Jones would be more thought of. There was no doubt that he had more influence in that direction than Wren. He did not think that Robert Adam did anything more for Northumberland-house than build a wing in 1774. The old house, called Suffolk-house, was never pulled down, although much was added to it. The Strand front, rebuilt 1748-50, from the designs of Daniel Garrett, was burnt down in 1780.

Mr. POLLEN, in reply, said he knew some people supposed that the two Johns were in fact the same man, but he could not agree with that view, because John of Padua was certainly a musician, by all accounts, and he did not think John Thorpe ever played any instrument in his life. With regard to the Adams, their houses were not all set off in the same way with little medallions and ornaments outside. Last year he had to go to a large country house near Stamford, and he found that everything, down to the gate-posts at the lodge leading into the park, were evidently designed by Adam; he could recognise it in a moment. The house was a very plain simple building, with two wings, and there was nothing objectionable about it. He thought the houses of the Adelphi-terrace were very good also.

The CHAIRMAN, in proposing a vote of thanks to Mr. Pollen, said they were also much indebted to

Mr. Purdon Clarke for the beautiful manner in which the furniture and decorations at South Kensington were exhibited, and for the facilities given to the public to understand what they saw, by the preparation of the admirable hand-books by Mr. Pollen and others, which formed very valuable books of reference.

The vote of thanks having been passed unanimously,

Mr. POLLEN said he was greatly indebted to South Kensington for the most interesting portion of his paper, namely the slides. They were all made for him and lent to him by the Department, otherwise he should not have been able to get such a complete set.

NINTH ORDINARY MEETING.

Wednesday, February 9, 1898; Major-General Sir OWEN TUDOR BURNE, G.C.I.E., K.C.S.I., Chairman of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

- Birkin, W. A. G., Villa Victoria, The Park, Nottingham.
- Collins, James Tertius, J.P., Churchfield, Edgbaston, Birmingham.
- Jardine, Sir John, K.C.I.E., 34, Lancaster-gate, W.
- Kennedy, James, 15, Willow-road, Hampstead-heath, N.W.
- Lamb, Edmund G., M.A., Old Lodge, Salisbury.
- Spargo, Edmund, 3, Cable-street, Liverpool.

The following candidates were balloted for and duly elected Members of the Society:—

- Denny, George A., African City Properties Trust-buildings, Market-street (Room 26), Johannesburg, South Africa.
- Parkin, William, The Mount, Sheffield.
- Robus, Henry J., Brent-bridge-house, Hendon, N.W. and 20, Bucklersbury, E.C.
- Schunke-Hollway, Henry Charles, Plaisir de Merle, P.O. Paarl, Cape Colony.
- Scott, Ernest Kilburn, Gartmoor-gardens, Wimbledon-park, S.W.
- Wackrill, Alfred E., Surveyor-General's Office, Colombo, Ceylon.

The paper read was—

COMPENSATION TO WORKMEN.

By A. D. PROVAND, M.P.

Few questions of such importance to the working classes have been discussed, and the governing principles definitively settled in so short a time, as the liability of employers to compensate their workmen for injuries sustained

in the course of their employment. The liability of an employer was not heard of until the year 1837. The question is, therefore, only 50 years old, and the Workmen's Compensation Act passed by the House last year marks the beginning of—and, indeed, goes a long way towards—its permanent settlement.

It will probably be the most satisfactory way of dealing with this question to give a very brief history of what was done until the Employers' Liability Act was passed in 1880. Then some account of how that Act worked, and of what has taken place in connection with the various amending Bills that have been discussed in Parliament down to 1894, when the Liberal Government introduced their Bill.

There is an impression in the popular mind that the liability imposed by the Act of 1880 on employers was somehow a new and fresh liability from which, until then, they were free. A brief explanation will show that this is not the case. An employer was always liable under the common law for injury to a workman (but not to executors in the case of his death), much in the same way, though not to quite the same extent, as he was liable to any member of the public. In 1837, this liability was settled by the judgment given in the first case of a servant suing an employer for compensation, namely, that of *Priestley v. Fowler*, which limited the employer's liability to such accidents as were caused by the employer's own neglect or carelessness, and he was freed from liability to compensate for an accident caused to a workman by the act or negligence of any fellow workman engaged in the same employment, and this constituted what is known as "the doctrine of common employment." This doctrine, of which we have heard so much lately, was, in fact, invented by the Judge at that trial. The liability of employers either to their workmen or to the public did not extend to the executors of any person killed; that is to say, a claim for compensation was personal, and if an injured person died the claim died with him. To remedy this Lord Campbell passed an Act in 1846 extending the power to the executors of the deceased, of recovering compensation for the death of anyone by neglect or default. After this other cases found their way into Court, but under the common law the difficulties which stood in the way of workmen recovering anything proved to be almost insurmountable. Meanwhile the published statistics of the number killed and injured on railways and otherwise in the course of their employment brought the question

prominently before the public, and caused the House of Commons to appoint a Committee in 1876 to consider the matter. This Commission made certain recommendations, but nothing was done until 1880, when the Employers' Liability Act was passed, which modified the doctrine of common employment by increasing employers' liability to this extent, that it made them liable for defective plant or machinery, for the act or default of persons whom they had placed in authority over the workmen, or for a workman's compliance with regulations which led to accidents. Employers' liability is therefore not new; they have always been liable, but while other persons have to sue for compensation under the common law or Lord Campbell's Act, a workman had besides these special facilities given to him for this purpose by the Employers' Liability Act of 1880. This Act will be the law until July 1 next, and remain so thereafter until amended or repealed except in so far as it will then be supplanted by the Workmen's Compensation Act of last year.

It may be interesting to notice the several different ways in which a workman or his representatives may now sue in order to recover compensation for injury or death. An action may be commenced under the common law, or the executors of the deceased may sue under Lord Campbell's Act, or a suit may be entered under the Employers' Liability Act of 1880. After July 1 next action might still be taken by any of these three methods or by arbitration under the new Workmen's Compensation Act if the accident happened to any person coming within its scope. Of course it is almost unnecessary to say that each new change in the law has improved the position of workmen, and that after July 1 next no action would be taken except under the Workmen's Compensation Act or the Employers' Liability Act so far as the latter still remains law.

THE ACT OF 1880.

The Employers' Liability Act of 1880 was passed for seven years, and it has been since renewed annually. During the intervening years many Bills have been brought before Parliament by private Members and two Bills by the Governments of the day in 1887 and 1894. The Bill of 1887 was defeated on a division, and the Bill of 1894 was withdrawn. It may be said that the whole of the Bills which were introduced almost annually down to last Session (preceding the introduction of the Workmen's

Compensation Bill) sought to carry out to a large extent the views of the workmen's representatives, and the Government Bill of 1894 embodied nearly everything that the workmen considered they required. The principal features in all these Bills, more particularly the last one, was that they provided ample opportunities for a workman to go to law. One principal difference between the Act passed in 1880 and the Bill discussed in Parliament in 1894 was that the last-named offered more facilities for the creation of lawsuits than the former. What were thought to be improvements in the Bill of 1894 were only theoretically so, and had it passed they would have been found to be actual practical drawbacks. Making the compensation unlimited, extending the limits of time for giving notice in some cases, imposing no limit of time at all in others, and similar changes, merely created facilities to be taken advantage of by lawyers. Such concessions were illusory and would have caused enormous sums to be expended in legal expenses, and thus have proved a bar to workmen getting compensation.

There is nothing to me so remarkable as that workmen should believe they are likely to obtain advantages under any system whatever which admits of their easily going to law. They must know even better than others the helpless position in which a workman or his relatives are usually placed as the result of an accident. Financially the employer is usually strong, the workman almost invariably weak. The scene of the accident is usually altogether within the control of the employer, and the difficulties of workmen obtaining evidence either through fellow-workmen or otherwise are so great that it is not to be wondered at that they should have failed so often in making out their cases in Court. But it is remarkable that their leaders should, with something like unanimity, have advocated an Employers' Liability Bill of a character which could never have led to anything whatever except more lawsuits than had already taken place under the Act of 1880, with consequences more injurious to employers and more disastrous to the interests of workmen.

THE TWO WAYS OF DEALING WITH THE QUESTION.

After considering what has been done in regard to the question, it becomes plain that there have been two distinct and different policies as to how compensation for accidents should be legislated for. The general opinion

of workmen, so far as their views have been expressed by the officials of trade unions, has been against any law such as the Workmen's Compensation Act of last year. I am unaware of any workmen's representative having made a statement in favour of such a law before that Bill was introduced in Parliament. The other policy has been confined, I might say, to students of the question who have been giving their attention to the nature and causes of accidents, to the question of responsibility, and to the best methods of preventing them, and also of ensuring compensation to those injured or to the relatives of those killed. Their conclusions were that until employers were made liable for all accidents, and the compensation was secured to the injured workmen or the representatives of anyone killed, the question could not be finally settled. To effect this as fully as possible, lawsuits must be got rid of and some plan of ensuring the payment of the compensation adopted. The Workmen's Compensation Act passed last year largely meets the wishes of those who hold these views.

The opinions of those who advocated the two different policies were therefore, on some points, opposed to each other; and while the trades union representatives have held to their views, it has been plain to those—whom I may call the students of this question, from the discussions which have taken place—that their policy could not be successful, and that even, although the law might be amended in the direction they desired, it would only remain so temporarily, for the reason that such a law could not be satisfactory or final. This becomes clear when we consider the grounds on which they based their conclusions as to what an Employers' Liability Act should provide for.

Workmen were of the opinion that employers could be made liable for a very large proportion of accidents, and that large sums could be recovered by going into Court. There was also what I might call a supplementary opinion, to the effect that an Employers' Liability Bill should be a Bill to prevent accidents. I shall briefly examine these three reasons.

In 1888 a statement was prepared by the German Government showing the causes of the accidents by which 15,976 persons were either killed or disabled for more than three months, and the causes assigned were as follows:—In each 100 cases there were attributed to employers about 20, to workmen about 25, to both and to fellow workmen about 8,

and to all other causes about 47. According to the foregoing, there was only one accident in five for which the employer would have been held liable under our law of 1880. Those who manage the accident fund of the London and North-Western Railway say that less than one accident in ten which occurs would fall on the company under the law, and this is probably fairly correct in regard to all railways. At Tangye's engineering works, in Birmingham, they have had an accident fund for many years, the whole of which is provided by the firm without any contribution from the men. According to the chairman of the company, the compensation for which they would have been liable under the Act would have been less than 5 per cent. of what they voluntarily paid. The South Metropolitan Gas Company, which employs 3,600 men, have all accidents inquired into by a jury of 12 workmen, and they found they had very few accidents for which the Company would have been liable under the law. At the Elswick Works, at Newcastle, a fund is managed by a committee, two-thirds of whom are workmen, and their experience is that the employers would have been legally responsible for one in twenty of the accidents which occurred. These are, of course, only estimates, but there are some statistics regarding mines which bear on this point. In the report for 1896 of the Chief Inspector of Mines the number of prosecutions are given under the Mines Act against owners and managers and workmen employed in mines and quarries. The number of convictions against owners and managers for 1896 was 70. The number of convictions of workmen was 469. But these figures do not show the relative importance, because the offences of the owners and managers were chiefly technical. Their convictions were 5 in connection with safety lamps and explosives, whereas the convictions of the workmen in connection with safety lamps, explosives, and smoking were 227. The probability of accidents arising was, therefore, enormously greater by the action of workmen than of employers.

	Total Number of Actions.	Total Amounts Claimed.	Total Amounts Awarded.	Average sum Awarded per Action. (About)
		£	£	£ s.
England ..	3,062	484,283	129,280	42 0
Scotland ..	2,072	489,798	18,348	8 7
Ireland ..	307	36,668	6,356	20 14

Workmen are also mistaken in supposing they could recover large amounts through the Courts. There have been regular Parliamentary Returns furnished from 1881 to 1896, giving the results of the actions tried under the Act of 1880, and the preceding is a summary of the total results of the 16 years.

The above Table shows that of the sums claimed in England 26·69 per cent. was recovered; in Ireland 17·30 per cent., and in Scotland only 3·74 per cent. The Parliamentary Committee of 1886 reported that juries were sympathetic to workmen, and were disinclined to pay attention to the evidence of employers who were the defendants. Notwithstanding this, the above results show that the difficulties of recovery under the law were too great to be overcome, or that workmen sued for amounts for which they had no reasonable ground of action. This they do not admit, nor have they admitted that any large amounts were received by private settlement, although no doubt this was the case, as many actions would be entered and withdrawn on terms, but so far as is shown by the Parliamentary Returns of the cases that were tried the result could not have been profitable to the workmen, as the total amounts recovered would probably not on the average be sufficient to meet the expenses incurred. Workmen are therefore labouring under a delusion in supposing that any large sums could be recovered in actions against employers.

Regarding what I have called the supplementary opinion, held by workmen, namely, that an Employers' Liability Bill should be a Bill to prevent accidents, I am sure this is largely impossible. A Bill of the kind can only operate as a preventive to accidents from the liability to pay being a deterrent on the employer and compelling him to be careful in order to make his payments as small as possible. Beyond this it cannot operate to prevent accidents, but so far as this is possible an Act making it obligatory on employers to pay for all accidents would of course make it more likely that accidents would be prevented. But an Act of this kind, as I have said, was never asked for by any Trades Union or representative workman before the Compensation Bill of last year was introduced. Their idea of a Bill was one full of clauses under which they could take employers into Court. The prevention of accidents can only be adequately provided for by Acts passed expressly for that purpose. The Mines Regulation Act, the Factory and Work-

shops Acts, and many others are in part expressly designed for this purpose, and it would be as reasonable to speak of making them into Compensation Acts as to speak of a Liability Act being made into one for the prevention of accidents.

I have now briefly stated the origin of employers' liability; of the two entirely distinct policies for dealing with it held by workmen and by others, and the grounds on which their views are based. I have also touched upon the various steps and proceedings that have taken place down to the introduction of the Workmen's Compensation Act of last Session, and this I shall now deal with.

THE NEW ACT.

The Workmen's Compensation Act of last Session is a fresh departure in legislation, and is in furtherance of the policy of making employers liable for all accidents, and while the Act has certain limitations and is incomplete, it is nevertheless a movement in the right direction. We are now at least on the way to finally settle a question which has a direct bearing upon the conditions of labour as affecting all those who are employed by others, the number of these being about 13,000,000 to 14,000,000.

The new Act only applies to what are called dangerous trades (excepting that of seamen, the most dangerous of all), and these include about 6,000,000 workers, but it will no doubt cover a very large proportion of all the accidents which occur. As soon as the present Act is fairly working there will no doubt be an amending Act passed to include all the workers who do not come within its scope. The effect of the Act will in my opinion be more far-reaching than is generally expected.

During the discussions on this question we have become familiar with the doctrines of common employment, of contributory negligence by workmen, and of contracting out. Under the new Act the doctrine of common employment is abolished and contributory negligence can only be pleaded in a case where the injury to a workman is attributable to his own serious and wilful misconduct. Such cases will be very rare indeed because no amount of ordinary negligence can be considered as wilful misconduct. We have therefore substantially got quit of the pleas of common employment and of contributory negligence. On the other hand we shall likely hear more than ever about contracting out. It will probably be adopted to a much larger extent

than heretofore, as the Act is framed so as to assist in this being done.

I have already spoken as to the views held by workmen's representatives, and I may add that they are also strongly against contracting out, as well as against the insurance of workmen's compensation. Many of them have expressed the opinion that if the insurance of compensation risks is permitted it will make the employers careless. Workmen are mistaken in thinking that insurance works in this way. Experience proves that in every department where insurance is practicable it increases instead of weakening the responsibility of the person who insures; and examples of this can be given. Houses are, to-day, far better and more safely built as against the risk of fire than they were formerly, and they are so because owners are compelled to build under certain precautionary rules in order that insurance on the building and its contents may be effected. They have no choice in this because tenants will only rent premises which are not only insurable but are so on reasonable terms. The same is true in reference to ships. These are now built much safer and much better than formerly, in order to withstand the stress of storms. Here, again, the insurers have stepped in and said you must build ships according to our rules, so as to ensure greater endurance and stability, and the owner must comply because no one will put cargo into a ship that is not insurable. Neither the house owner nor the ship owner has any option in the matter. They must build in accordance with the underwriters rules, otherwise they could neither get a tenant nor cargo. This result will also follow in reference to the insurance of compensation. There are many employers who might be inclined to leave the risk of accident to chance, and if so, there are at least some that would be unable to pay compensation if they become liable. It is, therefore, clearly the interest of workmen that their compensation should be certain. To have this insured will create another interest that will protect it, that is to say, those who take the risk will see that the conditions under which the risk was taken are maintained. Those who are under the impression that employers will be permitted to become careless, and will allow their machinery and plant to run down, do not understand how insurance is carried out. The insurers will see that this is not done, and if there is any intentional or negligent adverse change of conditions, the policy might be cancelled. Insurance would become impossible if those who

insured were allowed to alter the character of the risk at their pleasure.

It is difficult to account for the objection of workmen to insurance, as it is indisputable that unless the compensation is insured, they will in many cases be unable to obtain it. Apart from the fact that there are thousands of small employers whom an accident involving the life of a single man would make bankrupt, there are other and far more serious risks connected with mining which may yet cause the Act to be amended so as to make insurance compulsory. Between 1860 and 1894 there were 31 accidents in mines, each of which cost an average of 135 lives, the total being about 4,100. One of the last of these was that which occurred in 1894 at the Albion pit, in Wales, in which the lives lost were about 400. In some such cases the mine owners may be rich enough to meet the compensation due on a large number of lives, but in many of them it is certain they could not do so. It, unfortunately, usually happens in such cases that everyone who might be able to say how the accident happened perished in it. In all these instances no compensation was paid by the employers, as it was impossible to prove they were liable. But this will not be the case under the new Act, the owner will be liable whatever may be the cause of the accident. Therefore, any miner—employed, as he may be, with hundreds of others—who does not see that insurance is in some way provided to meet the cost of a big accident, is deliberately sacrificing the protection which the law has provided for himself and his dependents, as it is certain that in many cases no compensation could be paid by the employer unless it was covered by insurance. On the other hand, if the risk has been covered, the compensation will be a first charge upon the sum due from the insurers, and it will be paid to the workmen, although the owners of the property may become bankrupt. In the face of such calamities as have happened—and will, in all human probability, happen again—it is inconceivable that the advisers of workmen should recommend them against having the risk insured, as this is the only way in which compensation can be made a certainty.

INSURING COMPENSATION FOR ACCIDENTS.

In the belief that insurance of compensation risks must in some way be effected, I come to consider how this may be done. There are many insurance companies which take accident risks, but I cannot think that those created by the Workmen's Compensation Act can

possibly be to any great extent given to these. The working expenses of accident offices are seldom less than 40 per cent. of the premiums paid. This fact should make it unlikely that much business can go to them because insurance by co-operative organisations could be managed at a small outlay compared with this. The expenses are chiefly travelling, canvassing, agency, and advertisements. No advertisements or canvassing and very little travelling or agency would be necessary in the working of mutual insurance schemes. Nor would they require large capital involving profits to shareholders, and they could therefore be carried on for a mere trifle compared with that of a company. Probably 4 or 5 per cent. of the total premiums would cover the costs of management. Now how is co-operative insurance likely to be done?

There are large classes of workmen who will be brought under the Workmen's Compensation Act. For example, the railway companies employ amongst them nearly 500,000 men, and if they were to join in one mutual scheme, the compensation risks could be covered and met by a relatively small premium. But it is not even necessary that all the railway companies should join, because each of the leading companies could easily form for itself a sufficiently strong association amongst its *employés* which would work equitably, smoothly, and economically in guaranteeing accident compensation. This might probably be the best way to carry out the work. Miners furnish another illustration. These have nine societies, who work through a central association at Wigan, for dealing with distress caused by mining accidents. These societies were established between 1863 and 1889, and according to the report of the 16th annual conference, which contains the latest figures I can procure, they had in 1895 a membership of 317,000, a revenue of £294,333, of which members subscribed £234,498, and colliery owners £32,867, and their accumulated funds amounted to £636,464. The new Act will, however, relieve a large proportion of the members' contributions, namely, £234,498, as the mine owners will now have to bear the compensation for accidents. These societies are endeavouring to come to some arrangement to continue in existence, and everyone who is favourable to co-operation amongst workmen must desire that this should be done. Their experience will show exactly what compensation will cost mine owners under the new Act, and a mutual insurance scheme, covering compensation to

all miners, could be carried out cheaply and efficiently. There are about 730,000 workmen employed in and about our coal, iron, and other mines, and about 115,000 employed in quarries. There are other trades employing large numbers of men who could join together with the same object as the railway companies and mine owners for the purpose of insuring compensation, but these two will serve as examples to show how this might be best effected.

The Act is intentionally framed to encourage contracting out, subject to certain conditions. These are stated in Clause 3, and appear to be so full and so favourable to workmen that it is unlikely they could place themselves outside the Act by any compromise scheme covering all contingencies which would prejudice their position; indeed, if any scheme did so the Act provides for its being terminated. Therefore, a scheme certified by the chief registrar of friendly societies, and approved by the workmen themselves, by ballot if necessary, in terms of Clause 3, must be taken as fairly certain to improve their position or it would not be accepted.

A drawback to the Act of 1880, and to all Bills brought forward previous to the Workmen's Compensation Act, was that the facilities for going to law were so numerous, and were taken advantage of to such an extent, that a large part of the amounts paid by the employers was intercepted by lawyers and did not reach the workmen as compensation. The Workmen's Compensation Act is not free from such risks, as there are many points which may have to be decided by an arbitrator; indeed, one accident might involve more than one arbitration, and it is clear that the operation of the Act will entail some friction, delay, and also expense, but whatever these risks may be, would be avoided under a scheme of arrangement between employers and workmen which worked automatically without delay and at a trifling expense. It is, therefore, highly probable that there will be contracting out at least in those occupations employing large numbers who can conveniently co-operate. On one hand you have the isolated position of each workman, on the other the advantages of combination. When an accident occurs you have possible trouble, delay, and expense; and, even assuming that the compensation is usually recovered promptly, there would nevertheless be failure in some cases, and men employed in some occupations—miners, for example—would at all times be harassed with doubt

that their compensation might not be forthcoming. This difficulty could of course be met in another way, namely, by a national system of insurance managed by a Government department; and it is certain that if workmen generally do not come to terms with employers so as to secure their compensation, and if there were any serious instances of it being unpaid there would at once be an active agitation in favour of a Government department undertaking the business. This, however, will not be until after the working of the Act has been tested both by those who remain within its provisions and also by those who contract out of them. No such scheme can, according to the Act, have anything to do with the condition of a workman's hiring, nor will it be necessary that every workman in the same employment should join. Some may prefer to stay out and take their chance under the Act, but it is not unlikely that workmen will be favourably inclined towards arrangements under which there would be no questions to adjudicate, consequently no arbitrations besides having their compensation guaranteed.

GENERAL FUNDS.

While employers may insure their liability to compensate for accidents without making any previous arrangements with their workmen there is another class of funds which it may be desirable to create, but which cannot be formed unless the workmen contract out, and it is likely that a number of such funds will arise out of the operation of the Workmen's Compensation Act. There are many funds connected with public works and different occupations made up by the joint contributions of employers and employed. Like the Miners' Permanent Benefit Societies, these funds were chiefly used for payments of compensation for accidents, but some of them also provided for sick pay and other allowances. The new Act will relieve all such funds from payments on account of future accidents, but there are some of them liable to payments on account of past accidents. For example, the Miners' Provident Association provides for 3,108 widows, and 4,332 orphans who have been made so by previous accidents. But besides the necessity of such funds being maintained in order to provide for liability already incurred there is a great deal of other work which may be undertaken by them. Under the Workmen's Compensation Act the loss by accidents which do not invalid workmen for more than a fortnight will have to be met by

themselves. There will also be sick allowances unconnected with accidents, allowances for out of work, for incapacity, and for old age. It is therefore probable that having regard to the obligations undertaken by many of these funds which will necessitate their maintenance, employers and employed will come to terms under the new Act, and mutually contribute on an agreed scale to meet all these liabilities as well as accident compensation out of one general fund. Such a scheme could be easily carried out by any large railway company or by the Miners' Provident Association, and the *employés* of the railways, mines, and quarries aggregate more than 1,300,000. Similar funds could be formed by different workshops engaged in the same or a similar business. For example, the shipbuilding yards might combine in a scheme of the kind, and although the difficulties of organisation would no doubt at first be greater than with miners and railwaymen, who have already had much experience, this does not represent any real difficulty. The new Act will include in the occupations covered by it about 6,000,000 workers, and it is already known that some, and probably a considerable number of them, will, as soon as the Act comes into operation, form joint general funds with their employers. Therefore, out of this Act there will arise a number of co-operative schemes for dealing not only with accidents, illness, and old age pensions, but perhaps also with want of work. The management of such funds would be to a very large extent within the control of the workmen themselves, and this fact makes it more likely that employers and employed will combine to create them. The effect of the Act will reach further than was generally believed likely when it was introduced, and I look upon it as certain in many occupations to lead to more harmonious working between employers and employed. To the great majority of workmen the power of making beneficial permanent economic arrangements to meet the vicissitudes to which they are liable, now made possible by the Workmen's Compensation Act will no doubt be taken full advantage of.

THE COST OF COMPENSATION.

Much of the severe language which has sometimes been employed in the discussion of this question has, I think, arisen from the personal application which has been given to it by the use of the words, "Employers' liability." It is certain the employer has to

pay, but the liability really belongs to the work carried out, and, therefore, we should call it "Employment liability." In doing so, we not only get rid of the personal reference, but we state the fact, because the amount paid as compensation for accidents is an outlay on the business the same as rent and wages, and, therefore, forms part of the cost of carrying out the work. This also conveys to the mind the fact that the liability varies in different cases. In some employments it is almost nominal, while in others it may amount to a considerable sum. In speaking of the amount which accident compensation will add to the cost of production, I believe it is usually exaggerated. Some years ago I made calculations extending over all occupations, and my conclusions were that the total liability per annum would not exceed one half per cent. of the total wages paid; that is to say, taking all occupations into account. This would mean a total annual outlay of about £3,000,000 sterling. But as the proportion of accidents to the numbers employed, and consequently to the amounts paid in wages, is decreasing, the compensation will become a relatively smaller percentage on our trade. Another point to be considered is that this will not be a fresh outlay; it has always had to be met by the lessened expenses of the workmen themselves in other ways or by the assistance of relatives, or by accident societies, or in the case of large mining accidents by public subscriptions and in extreme cases by the community itself, through the rates. It is therefore not a new liability placed upon our trade. In some occupations the cost of compensation can be calculated with reasonable certainty either upon the wages paid or upon the cost of the work done or articles manufactured. For example, railway companies have kept such full statistics for so many years that they already know what their accident compensation will amount to under the new Act. There was much discussion as to what compensation would cost mine owners, but the calculation is really a simple one. The number of fatalities amongst coal miners in 1896 was 1,007, and estimating that for three years their wages would amount to £200 each, this would make the compensation £201,400. Now the coals raised last year were 195,000,000 tons, and one farthing per ton would provide £203,125. But there would still be the injuries to deal with and assuming that they would cost as much as the fatal cases we have only a total charge of one halfpenny per ton on the coal raised to meet the mine owners' liabi-

lity under the Workmen's Compensation Act, a sum which is certainly far too small either to affect private consumers or manufacturing interests.

RELATIVE RISKS OF DIFFERENT OCCUPATIONS.

Mining is undoubtedly the most dangerous of all occupations on land, but the fatalities to sailors are far more numerous, and, indeed, I doubt if anyone who has not gone into the figures has any idea how fatal is the occupation of a sailor. In sailing vessels the annual fatalities equal 1 in every 78 employed. In steamers they are only 1 in 207. The fatalities in steamers are, therefore, only a little more than one-third of what they are in sailing ships. The average fatalities, taking sail and steam together, are 1 in 147. In recent years a diminution has taken place in the total fatalities at sea, chiefly brought about by the substitution of steam for sails, and they are so numerous in sailing vessels, that it makes us desire that the change should continue until there were no longer any sailing vessels at all. This, I fear, is too much to hope for, but the appalling character of these figures strikes us when we compare them with the number of fatal accidents in mines, as mining is known to be a most dangerous occupation. In 1896, the fatalities to miners were 1 in 682 employed. The average fatalities to seamen employed in sail and steam were 1 in 207, say about three and a half times as many as to miners. But the fatalities to sailors employed in sailing ships is 1 in 78, that is to say, nearly nine times more than miners. Sailors do not come within the scope of the Compensation Act. They will be dealt with by a separate Act for themselves, and although we know that whatever its provisions may be, they can only to a certain extent lessen the number of accidents, nevertheless they will secure compensation for sailors who are injured and for the relatives of those who are killed.

The risk of injury or death by accident is enormously greater in some occupations than in others; but notwithstanding this, workers appear to adopt different callings apparently without considering such risks. For this reason the liability to accident is hardly considered in the amount of wages paid. If it were taken into account, some occupations, for this reason alone, should receive much higher wages than others. But the fact is we find workers following dangerous occupations receiving no more wages than other workers

obtain in occupations which are almost free from risk. The ordinary person hardly differentiates between a workshop and a factory, but the differences are very great indeed. There are about 550,000 workers employed in workshops where they have no steam power and very little machinery, and the total fatalities reported last year amongst those so employed were only 3, or say 1, in 183,000 workers. But the case of factories is quite different. In these steam power and machinery are employed. Even in textile factories, which are probably the safest of all to work in, and which employ nearly 1,100,000 workers, the fatalities in 1896 were 69, or about 1 in 16,000 workers. In factories employed in the working of metals accidents are the most numerous and severe. But without giving separate statistics for each class of factory—and this could only be done approximately—the total figures for 1896 show that factories generally employed about 3,650,000 persons, and the fatalities in that year were 590, which is equal to 1 in 6,186 employed. Those employed in workshops may be taken to run the least risk of any workers where it may be said that there is any risk at all, and compared with sailors the difference is that there were only three fatalities last year in 550,000 persons in workshops, whereas there were 687 seamen killed or drowned out of 53,267 employed in sailing ships. These may be considered the two extremes of accident risks in occupations, and the contrast is startling. It means that the risk of loss of life by accident in the two occupations is 2,346 times greater on board of a sailing ship than in a workshop.

THE DECREASE OF ACCIDENTS.

Amid the differences of opinion as to the best way of meeting compensation for accidents there is one gratifying fact proved by official reports, namely, that there is now, and has been for many years past, a steady decrease in the number of accidents. The statistics of accidents in the two most dangerous of our employments, namely, that of miners and of men employed in railways, show a steady diminution of fatalities. In 1874 one railway *employé* was killed in proportion to each 320 employed. In 1896 the proportion was 1 in 1,040. In the case of miners the average number accidentally killed in each year between 1850 and 1855 was 1 in 232. The proportion in 1896 was 1 in 682. Therefore since 1855 the fatalities in mines in proportion to the number of men employed have decreased

by two-thirds, that is to say, there is now only one death by accident instead of three that there were 42 years ago, and in the case of railways the fatalities are less than one-third of what they were only 22 years ago. No sufficiently accurate statistics of injuries have been kept, and it is therefore impossible to say how many fewer there are now than there were in former years, but no doubt there has, in regard to them, been the same large diminution that there has been in fatalities. No doubt, also, a like decrease in the number of accidents has taken place in other occupations, but the statistics kept in regard to workshops and factories do not go back far enough to enable us to speak definitely with regard to them. Accidents were steadily diminishing in number long before we had the Employers' Liability Act, as it was not passed until 1880. The improved conditions of labour leading to fewer accidents were effected by better methods of conducting the various operations, by improvements in plant and machinery, and by compliance with the rules and regulations of the Mines Regulation Act, the Factory and Workshops Act, and other measures passed for the purpose of controlling the working of these industries.

DISCUSSION.

Mr. H. W. WOLFF said he was very much in agreement with Mr. Provand, but on one or two minor points he differed slightly from him. He did not think it was right to say that employers' liability existed before the Act; there was a liability under the common law, but it was not specifically an employers' liability. The abortive Bill of 1893 had some good effects, for he understood that though Mr. Asquith's arguments failed to convince the House of Lords, they had convinced many of the County-court Judges, and since then compensation had been awarded on a much more liberal scale. The generosity which the railway companies pleaded did not seem to be established by the facts. The best contribution they made was 25 per cent. of the workmen's contribution, or one-fifth of the total amount, but at the Brussels Conference on this subject, Mr. D'Arcy, representing several employers' corporations in France, said the employers were expected to contribute one-third. There was some difficulty in deciding what should be the amount of contribution, because there were two kinds of insurance to be provided for. There was the ordinary accident insurance which ought to fall on the workman himself, and then there was the employer's insurance — his liability for keeping the human flesh and bone in repair, the same

as he kept his machinery plant and building in repair. If these two were thrown together into one fund, it was difficult to say exactly what proportion each should bear. Mr. Provand said the proportion of accident which would be compensated for if the employer were liable for his own negligence only, would be 20 per cent., the exact figure, according to the German statistics, being 19·76; but if you took machinery accidents themselves, the proportion was raised to 32·96, and in agricultural employment to 61·62. He quite agreed that under the old Act very few convictions had been obtained, and that workmen had received a ridiculously small amount in comparison to the disablements they had suffered, but the amounts recovered at law were not the only test. The Act had had a considerable effect in causing amicable arrangements to be made, and the general effect of all the Acts which had been passed, and the discussions which had arisen in connection with them, had been to greatly reduce the number of accidents. The great point was that under the new Act, a fresh line had been taken. He quite agreed with Mr. Provand that it was not well to encourage litigation; the law was always against the small purse and always in favour of the defendant. It was a maxim in English law that it was better for a hundred rogues to escape than for one innocent man to be punished, and in these cases the employer was always the defendant, and from the beginning the law had been in favour of the employer and against the workman. The workman had nothing to rely on but his employment, for which he was dependent on the employer; if he quarrelled with him, he might get his compensation, but he would lose his employment. The report of the Royal Commission, and the evidence adduced before it, showed that the old principle was condemned by everyone except the lawyers. Looking to foreign countries, it would seem that they began as we did, but had seen reason to alter their course. In Prussia it was found that they could not go on as they had; that the workman could not go on a warfare at his own cost. He got wages for his work, but did not get any allowance for the risks he ran, and the theory of the Manchester school that the risk of accidents was included in the wages was now acknowledged to be altogether untenable. A man might work for a day and receive 1s., and in that day he might suffer an injury to the amount of £100 or £200, or more. Up to the day of his death Lord Monk Bretton thought the Employers' Liability Act a masterpiece of legislation, but all other nations had proceeded more or less on the German model, which rejected our procedure by litigation founded on negligence, and adopted the principle of insurance. France and Italy fought against it as long as they could, but every year had seen them come closer to the German model. He did not approve of all the details of the German machinery, but the principle was sound, that of making the risk of accident a tax on production. It was not the employer but the employment which should bear the burden, and of course the consumer

paid it in the long run. As had been stated in Parliament this was not purely a labourer's question, because the industrial cripples were thrown on the rates and that was a hardship on the community at large. The amount wrongfully put upon the rate-payers in this way might be roughly estimated by taking the result of the special inquiry on the subject, made in Germany, from which it appeared that the rates were relieved in consequence of the Accidents Insurance Act to the extent of from 25 to 30 per cent. in some places; in one case they were reduced from 3·2 to 2·3 marks. Denmark, Norway, Austria, France, Belgium, and at last Italy, were all adopting the principle of insurance instead of making it a question of negligence, and that got rid of a good deal of disagreeable business, and united the employers and the employed in endeavouring to minimise accidents. In Germany it was stated that 53·13 per cent. of industrial accidents were preventible, and of agricultural 65·49 per cent.; and if machinery accidents only were reckoned the proportion preventible were, industrial 82·46 per cent., and agricultural 90·55 per cent. In fact, where you could make it people's interest to avoid accidents, they could be reduced to almost none. There was a co-operative society of workmen in Milan, with which he was well acquainted; it did all sorts of masonry and building work, and consisted of some 3,000 members. Theirs was reckoned one of the dangerous employments, and they ran considerable risks; but whenever he went there he always asked what accidents they had had, and the answer always was, none to speak of. The only serious accident within the last few years was one to an apprentice, who got larking about in the dinner hour on the end of a beam, lost his balance, and fell down. Being their own employers, they had an interest in avoiding accidents, and they managed to do so. In Germany and Austria they endeavoured to make it the interest of all employers to avoid accidents by grouping a large number together, and making them all liable jointly. In some cases, the whole trade was grouped together; in others—which was probably a better plan—the whole of a district. If there were 1,000 employers grouped together, the negligence of any one might bring a liability upon the whole, and therefore they were all interested in seeing that proper precautions were taken and appliances used, and the one in default could not plead, as he could as against a factory inspector, that he was an expert and knew best. How Mr. Chamberlain could have said that the principle of making 1,000 men liable for the default of one was opposed to English habits, he could not understand, for frank-pledge was a thoroughly Anglo-Saxon institution. This arrangement also met another serious difficulty, as it insured a fund out of which compensation could be paid. It was to meet this and to equalise the burden that so many favoured what was called "contracting out." He did not like contracting out, though he admitted

that the workman obtained certain advantages by it, because it created a state of dependence in the workman which was not natural. If he left his employment he lost his contributions, and thus he was to some extent at the employer's mercy. But the danger of employers not being able to meet their liabilities was by no means visionary. Cases had not actually occurred because in severe accidents it was generally impossible to prove liability. In mining accidents all evidence of negligence generally disappeared. But in France and in Belgium it had occurred that the employer was not able to meet the liability thrown upon him. He thought it was a grievous hardship on working men that in the Act builders of houses under 30 ft. high should be exempt. Those men ran the same risks as their brethren employed on larger works, in fact more, because the small employer would probably have worse scaffolding and implements, and the men had less constant employment. The exemption was justified on the ground that these small employers were so little better off than their workmen that they could not be expected to pay compensation; but if the employers were grouped together, as in Germany and Austria, a fund would be created, and the difficulty would be got over. Under individual liability, many employers would pay willingly and liberally, but others would be neither able nor willing, and they would bring pressure to bear on the workman to accept less than he was entitled to. He could not say that he strongly approved of the last Act, but he was very glad that it had been passed, though it was full of faults. What the Government had to do was to adopt a new principle and to give legislative sanction to it by a majority so large that no one could call it in question, and that they had done; and once the ball had been set rolling it would not stop until it came to the end of its course. The great advantage had been gained that employers, who, under other circumstances, would have criticised and opposed the measure, had now found it to their interest to improve it, and it was remarkable what a change in public opinion had been already produced. He found, in speaking to Members of Parliament, that many who began by disliking it had come to quite a contrary view; and this change of opinion augured well for future progress in legislation of this character. They had got away from a vicious principle, and secured for the workmen of England a very great boon. He had just received a copy of an Act which passed the Danish Rigsdag last month; it adopted the principle of the English Act but avoided two blemishes. It absolutely forbade contracting out, and it created a council which was to watch over the Act, and apply it administratively, so as to avoid all litigation; everything being managed by a Board, on which employers and workmen were to be equally represented.

Mr. ALEXANDER SIEMENS said he only wished to speak on one point, and that was to protest against

the tone of the paper in certain portions, which seemed to assume that there must be an antagonism of interest between employer and employed; as for instance where it referred to the difficulty of the workmen getting evidence. Professional agitators had made it their business to sow dissension between workmen and employers, and always to speak as if the interests of the employers and workmen were opposed to each other, and as if the employer was the natural enemy of the workman, which was a perfect fallacy. It was the so-called leaders of the working men who were the enemies of the employers. In many works which he could name there were funds established to provide pensions for old age, to which the workmen contributed nothing, and for sickness, to which they did generally contribute something. As regards accidents, any employer who had any sense would, without any Act of Parliament, adopt every means in his power to prevent accidents, just as the workmen's society referred to by Mr. Wolff did. They did so because it paid them in the long run, it was not a matter of sentiment, but of £ s. d., and he must protest against the notion that the employer was the enemy of the workman. He agreed with the principle that the employment should be at the expense of the accident. As the buildings and machinery had to be kept in repair, so ought the workmen; and he was quite willing to do that for his workmen, and, of course, charge his customers accordingly. It was not right that the cost of accidents should fall on the rates.

Mr. W. SHEPHERD (President of the Central Association of Master Builders of London) said he had something to do with the consideration of this Bill when it was before the Committee of the House of Commons, and he might say that not one of the members of the Government who were more immediately responsible for it ever contended that it could be defended on principle. Now that it was passed, however, it was not much use discussing it, and he thought the paper really admitted of very little criticism. The ideas put forward were rather subjects for consideration. He had himself thought that the true solution of the difficulty in working the Bill was to be found in the mutual association of workmen and employers. A great deal had been said about the Employers' Liability Act of 1880, but, as Mr. Wolff had pointed out, the number of cases tried under it was no indication of the number in which settlements had been made. In connection with their Association was an Employers' Assurance Association for meeting cases under the Act, and the principle they invariably acted upon was in case of an accident to avoid litigation if possible by coming to a reasonable settlement. In nine cases out of ten when there was an appeal from the Judge of the County-court his decision was reversed, showing that the workmen got the full benefit of the Act. If the employer succeeded he could not get his costs from the plaintiff, so that it

was always to his interest to settle if possible, especially as the jury always sympathised with the workman. If arbitration were to take the place of litigation he did not see how the award could be enforced without litigation. He hoped workmen would see that it was their interest to provide for the payment of compensation for accidents, and to spread the liability over a large area. If they were dependent on individual employers, in many instances the workman would never recover what was his due. He quite agreed that small builders should not be exempted from the Act; the workmen employed by them ought to be in as good a position as any others, but it was not the fact that accidents were more numerous in connection with small buildings; their insurance experience showed the contrary.

Mr. WOLFF said he had intended to refer to the Master Builders' Association, as an instance showing the advantages of combination. In his opinion, it was very important to avoid litigation, with its attendant expenses.

The CHAIRMAN, in proposing a vote of thanks to Mr. Provand, said he objected very much to the grandmotherly legislation to which we had been subjected by successive Governments to interference between employers and employed, and between landlord and tenant, but he must admit that he had been much struck by the views advanced in this paper, and he thought a system of mutual insurance would be extremely valuable, not only in promoting good feeling, but in bringing home a sense of responsibility to the workmen, who, in his opinion, were chiefly responsible for accidents.

The vote of thanks having been carried unanimously,

Mr. PROVAND, in reply, said he thought the principle of making production pay for the cost of accidents, was one which could be thoroughly defended. The risks run by workmen were certainly not included in the wages he received. During the discussions in the House they heard a certain Latin quotation repeated until they were tired of it, to the effect that when a man accepted an employment he must be held to know and take it subject to all the risks, and must put up with the consequences. That was laid down by a judge great many years ago, and his language had been quoted many times since, but he did not think it would pass current much longer. In the case of the Fort Bridge, he had calculated that compensation for all the accidents which occurred in connection with it would have amounted to about £100,000, and the bridge cost between three and four millions. Was it not better that the owners should pay interest of an additional £100,000, than that scores of men should go about as helpless cripples, and scores of widows and children be thrown on the rates. He had made

similar calculation with regard to the Manchester Ship Canal; compensation for accidents would be a microscopical sum in comparison to the gross expenditure on such work. Reference had been made to appeals from the County-courts to the High Courts, and he might say that whenever a case went to the High Court, no workman ever got sixpence out of it; it then became purely a fight for costs. There was an accident at Nine Elms a few years ago, which went to the High Court six or seven times in all, but long before the first trial had finished, the workman himself had lost all interest in it; he could never get a copper, it was purely a battle of the lawyers for costs. If ever a man got anything by the Act, it was either by a settlement, or in the County-court. Noticing remarks made by Mr. Shepherd, he hoped when the Compensation Act came into force the master builders would be able to establish such a strong mutual insurance society, that any man who was injured would have his compensation insured to him, and that they would be able to work it cheaply themselves instead of paying premiums to a company which expended 40 per cent. of its receipts in advertisements and canvassing. Nothing was further from his intention than to suggest that employers and employed were or should be at enmity; such a condition of things was hateful and unnecessary. Mr. Siemens represented a class of employers, of whom there were many, who dealt justly and generously with their men, but there were others who did not belong to that class at all. A case came before the Home Secretary last year in which several persons had been discharged from their employment for giving evidence. A man who had been injured in an accident was rarely capable of taking his own part against his employer. He had no doubt that great advantage had arisen from the discussion occasioned by the various Acts, which brought the question home to many who had never thought about it before. Mr. Wolff said some employers paid too little towards the accident funds, but he could mention several cases in which they paid it all—such as Messrs. Tangye's, and at the London Docks. The London and North-Western Railway Company contributed about seven-sixteenths and the men nine-sixteenths. The London and Brighton company last year paid £9,492, of which £2,722 only came from the men. But in other cases the employers were not so liberal. For example, the mine owners contributed only about 1 per cent. of the funds of the Miners' Permanent Relief societies. The Compensation Act was by no means perfect—for instance, it did not apply to diseases caused by unhealthy occupations. In 1896 there were 1,040 cases of lead-poisoning and anthrax reported, some of which resulted fatally, and under this Act nothing could be recovered in such cases unless a Judge decided that lead-poisoning was an "accident" within the meaning of the Act, which he did not think probable. There were other imitations, such as that with regard to the height of buildings, and some others with regard to machinery, which he hoped to see removed.

Miscellaneous.

BOOKBINDING EXHIBITION.

The Exhibition of Foreign and English Bookbindings, in the Reading-room of the Society of Arts, was closed on Monday evening, 7th inst., after having been open for a fortnight. The collection consisted of Pali MSS. lent by the Secretary of State for India; Japanese books lent by Mr. Charles Holme; a Persian binding of the 16th century, and a frame of Persian stamps and tools, with three covers made from these stamps, and some old bindings of the 11th, 12th, and 14th century, lent by the Science and Art Department; stamped bindings lent by Mr. E. Gordon Duff, &c.; embroidered bindings lent by Mr. Alfred Huth, Mr. Charles Elton, Q.C., and the Science and Art Department; two tortoiseshell book covers lent by Mr. Cyril Davenport and the Science and Art Department. There were two cases containing French bindings, one of Italian, and three of English, the books being lent by Mr. Edward Almack, Mr. Bain, Mr. Charles Elton, Q.C., Mr. Alfred Huth, Messrs. J. and J. Leighton, Mr. Alexander Neale, Mr. A. W. Pollard, Mr. Henry S. Richardson, and Mr. H. B. Wheatley. A catalogue of the exhibition has been printed, and copies will be sent to members on application.

The Pali MSS. from the India-office (Nos. 1 to 3) are on palm leaves strung together, with ornamental gilt end boards; two of these were from the King of Burmah's collection taken at Mandalay. These can scarcely be called books or the loose strings and board bindings, but they form an interesting link in the evolution of the Book. The Japanese specimens (Nos. 4 to 9) also show the changes in the form of books, first there is the roll (*makimono*), then there is the folding of the roll into squares, resulting in the more convenient form of a book opening out in a zigzag, sometimes the reading and illustrations are on one side only, but in other cases they are found on both sides. This form is called *orihon*. Mr. Holme also showed a volume bound in brocade which was stitched in the Western manner, and also one in the Japanese manner (*shomoton*), that is an overcasting which necessitates a considerable margin in the book, so that the print of the inside of the leaf should not be cut into. The Mediæval bindings from the South Kensington Museum consisted of an important volume (manuscript obituary of a religious house, No. 130) with a cover of gilt metal, decorated with Champlevé enamel, and set with engraved gems and cabochon crystals; in the centre a group of two saints in repoussé or beaten work. This very fine binding is German, and is supposed to belong to the 12th or 13th century. A volume of the first half of the 15th century (No. 132), also German work—MS. on vellum in oak

boards, the upper of which is covered with thin plates of gilt metal, some pierced with tracery, the corners ornamented with two intaglios, a cameo and a hemisphere of glass (probably covering a relic), set in raised collets surrounded by foliated bosses. The work is of the first half of the 15th century, but two of the gems are of older date. Of a totally different style of ornamentation is a painted book cover (No. 131), such as was used during the 14th and 15th centuries to bind the official account-books of the municipality of Siena. This wood cover is painted in tempera, on which is shown a friar in white gown and hood seated at a table counting money, the lower half occupied by an inscription in fine Lombardic characters. At each corner is a metal boss, and in the middle a leathern hinge band decorated with a graceful floral pattern in white on a red ground. The inscription is to the effect that it was the book of Friar Meo, chamberlain of the Tax-office, and that it occupied six months, 1309-10, during the term of office of Messer Guido da Tripli, Chief Magistrate of Siena.

No. 129 is curious as being a copy of the Vulgate translation of the Bible published in Paris in 1552, which is bound in red leather and has on the cover two plaques of bone, carved in open work with foliated ornaments, probably German work of the 10th or 11th century.

One case was devoted to the fine collection of stamped English bindings lent by Mr. E. Gordon Duff. Here the finest specimen was one bound by John Reynes, *circa* 1520, with the arms of the Redeemer of the World on the front cover and the royal arms and Tudor rose on the end cover. Another specimen of the binding of John Reynes was ornamented with two large panel stamps, that on the front cover representing the baptism of Christ and that on the end cover St. George and the Dragon; there was also an English panel with Tudor rose in the centre, *circa* 1493, bound by Richard Pynson. The stamps on these books are finely cut, and the impressions from them very brilliant; the books also are in a fine state of preservation. There were also some good specimens of foreign stamped bindings, some of which bore the names of the binders, as Martin Vulcanius, Johannes Bollicaert, Johan Norins, Laurentius de Pape, and André Boule. There were also exhibited specimens of embroidered bindings, tortoiseshell covers, &c.

ITALIAN.

Among the books from the South Kensington Museum was a manuscript on vellum (No. 124) containing the Decrees of the "Council of Ten," in stamped leather covers, panelled, painted, and gilt. This Venetian binding of the middle of the 16th century is particularly interesting as showing the overwhelming influence of Persian and other gilt bindings on the Italian style (as gilt bindings originally came from Italy), on those of France and her European countries. Mr. Huth exhibited a

singularly fine example from the library of Demetrius Canavari (No. 76), having the coloured medallion with which he adorned the sides of his books. There was another, but smaller, example from the South Kensington Museum (No. 135). Mr. Huth also lent a fine example from the library of Thomas Maioli which has the monogram of the collector in blind on the end cover, and the title, "C. Crispi Salustii Opera," and "Tho. Maioli et Amicorum," in cartouches on the front cover (No. 77). Other specimens of Italian bindings have the arms of two Cardinals, of Popes Julius III. and Clement XI., of Egidio Colonna, Archbishop of Amasia, and of the Doge Grimani. An aldine edition of the *Decameron* (1522) (No. 74) possesses the original inlaid side in gold and colour, with the motto: "Et mente e oculis." All these books were elaborately tooled many of them of specially characteristic Italian design.

FRENCH.

Amongst the specimens of French bindings exhibited, special mention should be made of a small volume in brown calf (No. 33), which has two medallions on the covers—one the head of Francis I. "Rex F." on the front cover, and Dido on the back cover. Although not so elaborately tooled, it has some likeness in part of the ornament to a specimen from the library of Francis I., figured in Gruel, *Manuel de l'Amateur des Reliures*. Two specimens from Grolier's library (Nos. 38 and 39), on a small volume in brown calf, probably bound in Italy before the collector adopted the style which is so closely connected with his name, and another volume in brown morocco with the title of the book the possessor's name, and his motto on the sides. The last belongs to Mr. Huth, who also contributed a superb specimen of Le Gascon's art (No. 55). This was a small volume in red morocco inlaid with olive and citron morocco beautifully tooled all over in the *pointillé* manner, with gilt edges painted in colour. Two very pretty volumes were shown which were decorated in Le Gascon's manner (Nos. 36 and 37). There were four volumes from De Thou's library, two with his own arms alone, one with his arms and those of his first wife, Marie Barbançon, and another with his arms and those of his second wife, Gasparde de La Chastre.

There were two volumes in the style of Clovis Eve (Nos. 52 and 52*), one with floral sprays on the back and sides, and the other in the more geometric pattern with floral sprays interspersed. A volume (No. 47) in brown morocco with the arms of France and Navarre under one crown on the sides, and the side and back covered with a *semée* of crowned L's and fleurs de lys is very similar to a binding executed by Clovis Eve for Louis XIII. which is figured in Gruel *Manuel de l'Amateur des Reliures*, except that the latter has not any arms on the sides. There was a small volume (No. 46) in mottled calf with the arms of Madame de Pompadour on the sides. But the

three castles that she bore ought to have the door of each open, and in this example the door is shut. There is a tradition that on one occasion the binder sent home some books to the Marchioness on the covers of which this blunder had been made. The lady stormed and threatened to return the books to the binder. It is not reported if she did so, but this is one of the books.

There was a series of pretty little books in coloured bindings with elaborate tooling in various designs, all of Lyonnese workmanship. Nos. 58 to 66 lent by Mr. Charles Elton, and Nos. 56, 57 by Messrs. J. and J. Leighton. Several specimens of bindings by Derome were exhibited, one in particular, belonging to Mr. Elton, has a very fine border on the sides decorated in the manner known as "dentelle à l'oiseau" (No. 53). The celebrated binders Ruette and Padeloup were also represented, and Mr. Bain lent a fine specimen of the work of Bozerian, which is seldom seen to such advantage. The book is in blue morocco, having a richly tooled back with small red inlays and a decorated border round each of the sides.

ENGLISH.

The three cases devoted to English gilt bindings contained a considerable number of beautiful examples, which, if compared with the French examples, stood the comparison well. One of the earliest bindings here was a pretty little volume in brown calf, with gold and black decoration, and the initials W. B. on the sides, which is attributed to Thomas Berthelet (No. 120). There are signs of a strong foreign influence in the binding of this little book, but we know that Berthelet, who was originally a Frenchman, was thus influenced. Another early example is found in No. 85, a volume in brown calf, with the device of Anne Boleyn, *i.e.*, a crowned falcon holding a sceptre and bush of red and white roses on the sides. This book was probably bound for Queen Elizabeth, who often bore her mother's badge.

There was a Bible (1616) bound in morocco and richly tooled for James I., and afterwards in the possession of the Parliamentary-General, Lord Fairfax (No. 93); and an edition of Bishop Andrews's Sermons (1631), which was Charles I.'s copy, and is interesting as having been one of the books recommended by the king to his children when he parted from them before his execution. Two little books also lent by Mr. Edward Almack (Nos. 86 and 87) were of great interest as being probably the work of an unregistered English binder, *viz.*, Samuel Brown, at the Hague. The Electra of Sophocles presented to her Highness the Lady Elizabeth by C[hristopher] W[ase], and the Latin translation of the *Εἰκὼν Βασιλική*. Both books were printed at the Hague for Samuel Brown in 1649, and are in a similar style of ornamental binding in black morocco. Mr. Almack also lent various editions of the *Εἰκὼν Βασιλική* bound in several styles; one has a medallion portrait of Charles I. on the sides (No. 90), another

was bound for Charles II. by Samuel Mearne (No. 91), and one which belonged to Queen Charlotte, was bound in black morocco with a diamond design (No. 108). This last has been supposed by some to be a French binding, but French styles considerably influenced English binding at this time, and similar tooling can be found on other English books, so that there seems to be no real reason for doubting its English origin. Besides these there were a large number of fine English bindings with very beautiful tooling which exhibit good taste, excellent workmanship, and a great variety of design. It is impossible to attribute many of them to any particular binder, but of binders who have gained fame good examples were exhibited of the works of Kalthoerber and Roger Payne.

Correspondence.

BOADICEA'S CHARIOT.

The model of a group of statuary of Boadicea, by Thornycroft, is put up at the corner of Westminster-bridge for the approval, I believe of the public, before casting a permanent representation of the same. As regards the general merit of the group, I have nothing to say at present, but the chariot there placed is no credit to the art and manufacture of ancient Britain. I think it is not like the chariot in which Boadicea stood or sat at the time of her celebrated speech. It does not represent a British chariot which, as we know, Cicero, writing from Rome to his friend Trebatius in Britain, says, "there seemed little worth bringing from Britain except the chariots, will you bring me one by way of a pattern."

This superior chariot was described by Cæsar and other writers, who are quoted by Ginzrot in his "History of Ancient Vehicles," published at Munich, 1817, by order of King Louis of Bavaria. Ginzrot was his Master of the Horse. In his work he gives a picture of the British chariot, which was almost identical with the Gaulish and Belgian chariots, and was doubtless derived from their original waggons of Central Asia, as described by Tacitus. Cæsar tells us that the British chariots were larger than the Roman chariots, were high behind, and were ascended from the front, and were provided with a seat; the pole was broad and flat, and upon it the charioteer stood or sat whilst he drove the horses, and would run along the pole and leap to the front of his horses when he arrived on the battlefield, whilst the warrior or warriors fought from the inside of the chariot. The chariot of Mr. Thornycroft is quite contrary to the description given by Cæsar, and is too small and clumsy. A fuller account than I have written here will be found in my lectures on "Coaches," delivered at the Society of Arts.

The Roman and Greek chariots were copied from the Egyptian chariots. In Persia, from sculptures on ancient monuments still extant, both the Gaulish and

Egyptian style of chariot appear to have been used. But the Persian chariots were all on a larger scale, with massive wheels.

GEORGE A. THRUPP.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock:—

FEBRUARY 16.—“The Protection of Industrial Property.” By J. F. ISELIN, M.A., LL.M. Sir FREDERICK BRAMWELL, Bart., D.C.L., F.R.S., will preside.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock:—

FEBRUARY 17.—“The Plague in Bombay.” By HERBERT MILLS BIRDWOOD, C.S.I., M.A., LL.D. (late Governor's Council, Bombay). The Right Hon. EARL SPENCER, K.G., will preside.

CANTOR LECTURES.

Monday Evenings, at Eight o'clock:—

HUGH STANNUS, “The Principles of Design in Form.” Four Lectures.

LECTURE I.—FEBRUARY 14.—Construction, Symmetry, Balance, &c.

LECTURE II.—FEBRUARY 21.—Gradation, Proportion, Scale, &c.

LECTURE III.—FEBRUARY 28.—Repetition, Alternation, Axiality, &c.

LECTURE IV.—MARCH 7.—Simplicity, Reticence, Unity, &c.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEB. 14... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Hugh Stannus, “The Principles of Design in Form.” (Lecture I.)

Imperial Institute, South Kensington, 8½ p.m. Lieut. J. P. Mackesy, “Sierra Leone.”

Geographical, University of London, Burlington-gardens, W., 8½ p.m.

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Prof. John Milne, “Geological Changes beneath the Ocean.”

TUESDAY, FEB. 15... Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. Ray Lankester, “The Simplest Living Things.” (Lecture V.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. P. M. Crosthwaite, “The Stability of Channels through Sandy Estuaries.”

Statistical, in the Theatre of the United Service Institution, Whitehall, S.W., 5 p.m. Mr. Edwin Cannan, “Demographic Statistics of the United Kingdom: Their Want of Correlation and other Defects.”

Pathological, 20, Hanover-square, W., 8½ p.m.

Photographic, 12, Hanover-square, W., 8 p.m. Mr. Wallace L. Crowley, “Process Reproduction from an Editor's Point of View.”

Zoological, 3, Hanover-square, W., 8½ p.m. 1. Mr. W. P. Pycraft, “The Osteology of the Steganopodes.” 2. Dr. W. G. Ridewood, “The Skeleton of the Regenerated Limbs of the Midwife-Toad (*Alytes obstetricans*).” 3. Mr. G. A. Boulenger, “Description of a New Sea-Snake from Borneo.”

WEDNESDAY, FEB. 16... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. J. F. Iselin, “The Protection of Industrial Property.”

Meteorological, 25, Great George-street, S.W., 7 p.m. 1. Mr. Edward Mawley, “Report on the Phenological Observations for 1897.” 2. Mr. John Hopkinson, “Monthly and Annual Rainfall in the British Empire, 1877 to 1896.”

Microscopical, 20, Hanover-square, W., 8 p.m. Mr. T. C. White, “Micro-crystallography.” 2. Exhibition of miscellaneous Lantern Slides by Mr. J. E. Barnard.

Patent Agents, 19, Southampton-buildings, W.C., 7½ p.m. 1. Discussion on the President's Opening Address. 2. Mr. G. B. Ellis, “The Merchandise Marks Act—Ten Years' Experience.”

Mining and Metallurgy, Geological Museum, Jermyn-street, S.W., 8 p.m. 1. Mr. Wm. Frecheville, “Notes of a Visit to the Gold Mines of Kalgoorlie Western Australia.” 2. Mr. Wm. Teague, “Notes on Shaft Sinking.” 3. Mr. W. Wybergh, “Diamond Drilling in the Transvaal.”

THURSDAY, FEB. 17... SOCIETY OF ARTS (East Conference-hall, Imperial Institute, South Kensington S.W.), 4½ p.m. (Indian Section.) Dr. Herbert Mills Birdwood, “The Plague in Bombay.”

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. F. N. Williams, “The genus *Arenaria*.” 2. Mr. G. S. West, “The Histology of the Salivary and Other Glands of the *Colubridæ*.”

Chemical, Burlington-house, W., 8 p.m. 1. Mr. J. T. Cundall, “Some Lecture Experiments.” 2. Messrs. W. A. Shenstone and W. T. Evans, “Observations on the Influence of the Silent Discharge of Electricity on Atmospheric Air.”

London Institution, Finsbury-circus, E.C., 6 p.m. Mr. Augustus Birrell, “Commercial Aspects of Fraud.” Royal Institution, Albemarle-street, W., 3 p.m. Dr. J. P. Richter, “Some Italian Pictures at the National Gallery.” (Lecture II.)

Historical, 28, Jermyn-street, S.W., 5 p.m. Annual Meeting.

Numismatic, 22, Albemarle-street, W., 7 p.m.

Camera Club, Charing-cross-road, W.C., 8½ p.m. Mr. Grant Allen, “The Adoration of the Magi.”

FRIDAY, FEB. 18... Royal Institution, Albemarle-street, 8 p.m. Weekly Meeting. 9 p.m. Prof. L. C. Miall, “A Yorkshire Moor.”

Quekett Microscopical Club, 20, Hanover-square, W., 8 p.m. Annual Meeting.

Geological, Burlington-house, W., 3 p.m. Annual Meeting.

SATURDAY, FEB. 19... Royal Institution, Albemarle-street, W., 3 p.m. Mr. William H. Hadow, “The Structure of Instrumental Music.” (Lecture II.)

CORRECTION.—Sir George Birdwood writes:—“There are one or two typographical and clerical errors in my memorandum of last week I should like to correct:—Section A, *kavita*—the specific Latin name, correctly printed, is *elephantum*; *wagati*, for ‘white’ substitute yellow. Section D, *bhavya*, the specific Latin name, correctly printed, is *speciosa*.”

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FRIDAY, FEBRUARY 18, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.

CANTOR LECTURES.

On Monday evening, 14th inst., Mr. HUGH STANNUS, F.R.I.B.A., delivered the first lecture of his course on "The Principles of Design in Form."

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

TENTH ORDINARY MEETING.

Wednesday, Feb. 16, 1898; Sir FREDERICK BRAMWELL, Bart., D.C.L., F.R.S., Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Atkinson, Alexander, Camp, *via* Jammu, Kashmir, India.

Purnell, Arthur Edward, 123, Harbut-road, New Wandsworth, S.W.

The following candidates were balloted for and duly elected Members of the Society:—

Bagley, Frederick Roberts, State Railways, Rangoon, Burma.

Baker, Charles John Seymour, 47, Redcliffe-square, South Kensington, S.W.

Pringle, Hon. John, M.D., Cape Clear, Clonmel P.O., Jamaica.

Pym, Douglas, Belle Vue Studio, Streatham, S.W.

Smith, Vere, St. Dunstan's College, Catford, S.E.

Wells, Commander Lionel, R.N., Fire Brigade Headquarters, Southwark, S.E.

Wirtz, Dr. Quirin, M.A., 28, Great Ormond-street, W.C.

Wright, John, junr., 3, Surbiton Park-terrace, Kingston-on-Thames.

The paper read was—

THE PROTECTION OF INDUSTRIAL PROPERTY.

By J. F. ISELIN.

The subject with which I propose to deal is one of no small importance. Yet it has hitherto attracted so little attention in this country that the title which I have given to this paper is not one which is generally known or understood, although it has been officially recognised by the Government of the country in treaties to which Great Britain is a party.

The term "Industrial Property," like many other general terms, is a French one. It expresses a conception which exists indeed in this country, but for which no generally accepted name has yet arisen.

There is a class of legal rights whose importance is almost wholly modern, which includes the right of an inventor to the fruits of his invention, of an author or artist to the work of literature or art which he has produced, of a trader to the mark which he uses to distinguish his goods, or to the name and goodwill of the business which have been made valuable by his skill and industry, and those of his partners and predecessors. These rights are in every respect analogous to ordinary rights of property, except, perhaps, that there is no material object to which they relate.

These rights are in French law comprised under the head of intellectual property (*propriété intellectuelle*), and this again is divided into literary and artistic property on the one hand, and industrial property on the other. The first of these corresponds almost exactly with what is called in England copyright, except that copyright in designs intended for manufacturing and industrial purposes would in France come under the head of industrial property. The French classification has made its way over the continent of Europe and is not without influence in this country also, because it is observed in the international treaties upon the subject. Literary and artistic works are protected by the Berne Convention of 1887, whilst patents, trade marks, and designs depend upon the Paris Convention of 1883, together with certain amendments made to it at Madrid in 1891. The subject of this paper is the latter only—that is to say, patents, trade marks, designs, and certain other rights of the same kind. And I intend to consider the subject almost entirely from an international point of view.

The subject can be conveniently dealt with in an historical manner. The practice of securing the fruits of an invention to the inventor by giving him an exclusive right to use it was introduced, I believe, by the Tudor kings of England. The use which was made of the power of granting patents by Queen Elizabeth and by James I. led to a very severe struggle between the Crown and Parliament, which was finally settled in 1621 by the passing of the Statute of Monopolies, whereby it was declared that "all monopolies and all commissions grants licenses charters and letters patent heretofore made or granted . . . of or for the sole buying selling making working or using of anything . . . are altogether contrary to the laws of this realm;" but an exception was made in favour of "letters patent and grants of privileges for the term of fourteen years or under, hereafter to be made, of the sole working or making of any manner of new manufactures within this realm, to the true and first inventor and inventors of such manufactures, which others at the time of making such letters patent and grants shall not use."

This provision is the basis of our existing Patent-law. In consequence of the point of view which I am taking, it is necessary to point out that the law has always been interpreted in a strictly national manner, so that the person who introduces a new manufacture into the country is regarded as entitled to a patent for it, even though it be admitted that the actual invention has been made in a foreign country by someone else.

The protection of trade marks was introduced by the Courts about the beginning of this century; that of designs was created by Act of Parliament in 1787. Numerous Acts of Parliament were subsequently passed dealing with all these subjects, and the whole law dealing with them all was consolidated and amended by the Patents, Designs, and Trade Marks Act of 1883. The other parts of industrial property have all come into special prominence during the last few years, and have been regulated partly by the decisions of the Courts, and partly by Acts of Parliament, the most important of which is undoubtedly the Merchandise Marks Act, 1887.

The reason which has made these subjects of special importance during the present century is the great growth of commerce and manufactures which began, roughly speaking, about the middle of the last century. But the movement for securing rights of industrial property for foreigners dates back only about a quarter

of a century. The first impulse was given in 1873. In that year a Congress was held at Vienna on the occasion of the International Exhibition, which appointed a committee to work for the realisation of the principles which had been then laid down. At a subsequent Congress, which was held in connection with the Paris Universal Exhibition of 1878, a project for the formation of an International Union for the Protection of Industrial Property was brought forward by the Austrian Society of Architects and Engineers. The Congress appointed a Permanent Commission to consider the project, and the French section of the Permanent Commission produced a draft which was laid before a diplomatic conference convened by the French Government in 1880, and served as the basis of the Treaty of Union, which was signed by 11 Powers (Belgium, Brazil, France, Guatemala, Italy, the Netherlands, Portugal, Salvador, Servia, Spain, and Switzerland) in 1883. The scope of the Union has since been widened by the adhesion of numerous other States (Great Britain, Tunis, and San Domingo in 1884, Sweden and Norway in 1885, the United States in 1887, and Denmark in 1894), so that it may now be said that the only great States which still remain outside it are Germany, Austria, and Russia, and of these Austria last year gave notice of her intention to become a member of the Union.

It will not, I think, serve any good purpose to give here the provisions of the Paris Convention in full, but it is necessary to give a short account of its main provisions.

It begins by constituting the States which are parties to it into a Union, which any State is entitled to join by giving notice to the Swiss Government. It is next provided that the subjects or citizens of any State which is a member of the Union shall enjoy in all the other contracting States all the advantages which the law of that country gives to natives as regards patents for inventions, industrial designs or models, trade marks, and trade names. This is carried out by giving to any person who applies for a patent, or registers a design or trade mark, a certain period (which is six months in the case of patents, and three in those of designs and trade marks) during which he enjoys a right of priority, and cannot be anticipated, or have his right destroyed, by the acts of other persons. The working of this provision may be shown by a simple example. A man patents an invention in France. Shortly after someone else takes out a patent for, or works, the invention in this country. The acts

of the second inventor will not be any obstacle to the grant or to the validity of a patent in England to the original inventor, provided he makes application before the period of six months has expired.

To meet the very harsh laws relating to the working of patents which exist in many countries, it is provided that patentees shall be entitled to import patented articles into the country where the patent has been granted without liability to the forfeiture, which the law sometimes decrees, as in France. On the other hand, the compulsory working clause—of the existence of which on the Continent so much complaint is made in this country and in the United States—is left unaffected.

As regards trade marks, it is provided that they shall be admitted for registration and protection in every State of the Union, "in the form originally registered in the country of origin." This article, and the preceding one—which deals with the compulsory working of patents—have been the subject of much difficulty and controversy ever since the convention was signed. I mention this here, shortly, because I intend to return to the subject later.

It is further provided that trade marks shall be protected in every country of the Union without any necessity for registration; whilst all goods falsely or unlawfully bearing a trade name or trade mark, or the name of a place with the addition of a fictitious trade name, or one borrowed with a fraudulent intention, are liable to seizure upon importation into a State of the Union.

Finally, the contracting States undertake to grant temporary protection to patentable inventions, industrial designs and models, and trade marks, which are shown at an international exhibition in their territory, and to establish a special government department of industrial property, and an office for the publication of patented inventions, designs, and trade marks. A central office was created at Berne, under the supervision of the Swiss Government, for the purpose of collecting and publishing information of all kinds relating to industrial property. The creation of this central office is perhaps not the least valuable result produced by the convention of Paris. It publishes a monthly journal, *La Propriété Industrielle*, which contains most valuable information, and it is at the present time engaged in publishing a collection of all the industrial property laws of the world.

The Convention provided for periodical

Conferences to revise and amend it. Three of these have been held up to the present. The first, which was held at Rome, in 1886, led to no result, and the amendments which were carried after much discussion and difference of opinion, were not ratified by the Governments of the contracting States.

The next, which met at Madrid four years after, was more successful. It produced four protocols. One was not ratified on account of the great opposition which it met in several States. Another has not yet been ratified by Servia and San Domingo and has, therefore, not yet come into force. A third relates to the substitution of a single registration at Berne for the many registrations which would otherwise be necessary in order to obtain complete legal protection for a trade mark in all the States of the Union. This is a mere question of administrative machinery, with which it is not necessary for us to concern ourselves, more particularly as for special reasons this country has hitherto been unable to become a party to it. The fourth, which is usually referred to as the Madrid arrangement, will require a little more consideration. This relates to what are called "false indications of origin" on goods—a subject which occupies a large place in the much discussed Merchandise Marks Act of 1887. It provides that all goods bearing an indication of origin which falsely describes any of the contracting States or a place situated in one of them as the place of origin of the goods shall be liable to seizure upon introduction into any of the contracting States. But it is provided that a seller shall not be prevented from placing his name or address on goods which come from a country different from that of sale, provided he at the same time clearly states where the goods actually come from. There is also an exception as regards place names which have become mere generic designations, and have thus ceased to be understood as indicating the place of origin of the goods—as, for example, Russian leather, Epsom salts, Brussels carpets. It is left to the Courts of the different countries to decide which these are, but by a remarkable inconsistency, which is probably destined to give rise to a good many difficulties, it is specially stated that "regional appellations relating to the products of the vine" shall not be liable to be considered as generic designations, but must always be considered as indicating the origin of the wines or spirits to which they are applied. On account, probably, of the stringency of these provisions, this protocol was signed only by seven Powers—

Brazil, France, Great Britain, Portugal, Spain, Switzerland, and Tunis.

The last of these Conferences was held at Brussels in December of last year. The result of its deliberations has not yet become generally known. I have applied to the Foreign Office for information, but have not yet received a definite reply. From another source it has come to my knowledge that four subjects of special importance and difficulty have been reserved for further discussion at a later meeting of the conference, which is to be held, if possible, in the course of the present year. These are: the right of priority, the compulsory working of patents, the conditions of registration of foreign trade marks, and what is called on the Continent of Europe, and in the United States, "unfair competition," although the name has not yet found acceptance in this country. The term is applied to all those numerous cases where a trader attempts to appropriate or to destroy a part of the goodwill of a rival's business, the results of his skill and industry, without directly using either his name or his trade mark.

Whilst the Governments were thus progressing, private individuals were not idle. Congresses were held at the Paris Exhibition of 1889 and the Chicago Exhibition of 1893, but they appear to have dealt rather with general principles than with practical details, and but little seems to have resulted from their deliberations.

A more important movement arose in Germany and Austria, and it is to this that I desire to direct special attention. It had occurred to some people in these countries that it was undesirable for them to continue to remain outside the Union. Societies for the Protection of Industrial Property were founded in Germany and Austria, and at a conference of these societies which was held at Berlin in October, 1896, it was decided that an International Association should be formed, on the model of the International Literary and Artistic Association, which brought about the Berne Copyright Convention, for the purpose of holding periodical Congresses for discussion, and of working for the extension and improvement of the existing Union and its treaties.

For this purpose negotiations were entered into with some of the most influential persons interested in the matter in England, France, and other countries, and a meeting was held at Brussels in May of last year, at which the Association was definitely constituted and provided with an executive com-

mittee. The first Congress of the Association was held at Vienna in October, and was attended by a large number of persons, including representatives of the French, German, Austrian, Belgian, and United States Governments, as well as of seventeen Continental Chambers of Commerce and many trade societies of great importance. I understand that the proposals which were adopted by the Congress were laid before the Diplomatic Conference which met in Brussels, and were to a great extent accepted. This Association, which was founded less than a year ago, now numbers about 400 members. It has up to the present not met with much success in this country, although it already includes some of the principal members of the Bar who are interested in these questions, and many of the principal patent agents.

I am persuaded that it has only to be better known to show the great service which it should be capable of doing in this country, where all matters connected with trade and commerce are always certain of receiving full and careful consideration.

It has been decided to hold the next Congress of the Association in London at the beginning of June. I have here several copies of the programme, which I shall be glad to give to any one who is sufficiently interested in the matter.

I should like, in conclusion, to give you one or two instances of the manner in which, as I think, the Association and its Congresses may be of use to British trade.

There is, first of all, the question of the compulsory working of patents, to which I have before alluded. In all countries, except England and the United States, it is provided with more or less stringency in the Patent law that every patented invention shall be worked in the country by the production of the patented article there, under penalty of forfeiture if the invention is not worked within a certain period, generally two years. In France the law is even more severe, and the patentee is forbidden to import the patented article into the country under penalty of forfeiture. In this country, on the other hand, we have only a provision empowering the Board of Trade to grant licenses to manufacturers to work patented inventions upon such conditions as the Board consider just, but only in cases which are so infrequent that, I believe, hitherto it has never been found necessary to make use of the provision. The most severe part of the French law, that relating to the importation of

patented articles, has, no doubt, been modified by the Convention of Paris; but the compulsory working clause remains intact both there and elsewhere. It is not unnatural, therefore, that manufacturers in this country consider themselves unfairly treated. Of late, opinion in Germany has become more and more opposed to the maintenance of the compulsory working clause; and a very able paper in this sense was read last year at the Vienna Congress by Mr. von Schütz, of the firm of Krupp. The opposition to its abolition comes from France and Belgium; yet, even there, it shows signs of giving way. The Association seems to me well qualified to help on the movement for the suppression of the compulsory working clause.

In regard to trade marks a position of no less difficulty has arisen. Although the Convention of Paris provides that trade marks, if duly registered in the country of origin, shall be admitted for registration and protection in every country of the Union *in the form originally registered*, and the Act of 1883 was supposed to be sufficient to carry it into effect, it was found that the Comptroller refused to register foreign trade marks unless they were such as the English law would recognise as trade marks. On two occasions an appeal was taken to the Courts, and on each occasion the Courts upheld the decision of the Comptroller. He therefore continues to exercise his jurisdiction in accordance with the anomalous standards of the English law, and it is commonly said in France that we have not carried out the obligations into which we entered by signing the Convention. The Congress of the Association should provide an opportunity for the discussion of the subject, and for the arrangement of measures for removing the injustice, if one exists.

Thirdly, there is the question of false indications of origin, or as we prefer to call them, false trade descriptions. It is a matter of common knowledge that in 1887 Parliament passed an Act of great stringency for the purpose of dealing with fraudulent descriptions of this kind. Everyone knows also that some people think that we are paying rather heavily for our (as they think) excessive honesty in this matter, and that a very fierce controversy has recently taken place on the subject. Nevertheless everyone is agreed that we should do our best to induce foreign nations to imitate us. The Congress will provide an opportunity of showing them how far we are

ahead of them, and of expressing our wishes that they should follow our example. In the meantime, however, we have entered into a treaty by which we are bound to protect the names of wine-growing countries against appropriation by persons outside them. Does our law ensure that this shall be done? There are circumstances which seem to cast a doubt upon it. Here again the Congress will afford an opportunity for discussion and consideration.

In 1896, Germany passed a law on the subject of unfair competition. The law contains a section providing that its benefits may be extended to the members of States which protect Germans by means of a notice in the Imperial Bulletin of Laws. There is no question that our law protects Germans, and that it is not less favourable than the German law. Yet the necessary notice extending protection to British subjects has not yet been issued, and one may perhaps believe that it is meant to be purchased by some further concession. The Association should afford the means of bringing pressure to bear upon the German Government.

Again, suppose a patentee has an invention which he wishes to patent in many countries. He will find that he has to comply with numerous and different sets of rules as to the form in which his application must be made, and often he will have to send in drawings of the same invention reduced to many different scales. Much may be done to help the inventor by making these regulations, particularly as to drawings, uniform—and this is the sort of work which the Association will do. Or an inventor's position as regards searching for anticipations of his invention may be improved by making the classification of patents in different countries uniform—and this also the Association proposes to do.

These matters seem to me of some importance. There must be many people to whom the proper decision of questions such as these is a matter of great pecuniary interest. These are but a few of the questions which are open for discussion. I have here a list of some more in the programme of the Congress. New ones are arising every day. If you take any interest in the subject, or in the Association and its Congress, I can give you as much more information as you please, and, may I add, the committee of the Congress will be glad of all the assistance you can give it.

DISCUSSION.

MR. ALEXANDER SIEMENS said the subject of industrial property was of extreme importance, and no doubt the International Association would be able to do a great deal of good work in elucidating it. One of the questions which required discussion was that of the preliminary examination of patents, which was insisted upon in Germany and the United States. That subject was well dealt with by Mr. Abel in his address as President of the Institution of Patent Agents on the 15th December, and he might mention some of the facts then brought forward. It was often said that the granting of a patent in either Germany or the United States was a guarantee to the inventor, and that a patent in either of those countries was more valuable than an English patent. Mr. Abel, however, produced figures which were very significant, and proved in fact that an inventor had no more guarantee that his patent was valid in Germany or America than he had in England. Taking patents which had been disputed in the Courts, during the year 1896, there were declared void in England 43 per cent., in Germany 42 per cent., in the United States 28 per cent., and in France 24 per cent. England and Germany were practically equal, and, though there was a smaller proportion in the United States, it was greater than in France, which had no preliminary examination. On the other hand, there were 43,000 patents taken out in the United States in 1896, against 12,000 in England, and 5,000 in Germany. The preliminary examination was a frightful tax on the inventor, both in time and money. His firm applied for a patent in the United States in 1879, and the obstacles and delay occasioned by the Patent-office dragged it on until about three years ago, when the patent was finally refused. In the year 1896 there were 12,530 patents granted in England, and in the same year 26 were disputed. In Germany, in the same year, 5,410 were granted, and 102 were disputed. In Germany, therefore, the inventor had no more certainty of his patent being held valid than in England, and he was delayed for a long time, on an average 14 or 16 months. With regard to the Merchandise Marks Act he was not at all sure that it was right to insist on the country of origin being marked on all goods. If he were asked to supply an article and procured it from someone else, and examined it and passed it on, he contended that he conferred the "artistic merit" upon it, and gave his customer a guarantee that the article had the required qualities. Take the case of electric insulators. They were made at potteries, and were sent to his works where they were examined electrically, and the defective ones were rejected, only good ones being supplied to a customer. Faults could not be detected simply by inspection nor cheaply enough by electrical testing, unless you had proper appliances and skilled workmen who could effect a thorough examination in a short time. Why should he have to put on those insulators, or the boxes in which they were sent

out, the information where he got them? It had happened, in consequence of this Merchandise Marks Act, that some customers, seeing they were obtained from abroad, had gone straight to the manufacturer and ordered them. They had done that once, and then come back to him, because the manufacturers themselves did not know how to test the insulators, and could not, with the best intentions in the world, select those which were really efficient. There were many cases where the same principle applied; where the much abused middleman really added some valuable quality to the article he sold, and by compelling him to indicate the place of origin, you gave his rival an advantage which in his opinion was not just; though he fully agreed that every fraud in description should be put down.

Admiral SELWYN said he spoke as an official of the Paris Congress on Industrial Property, being a Vice-President and head of the British Section. He strongly objected to the idea of compulsory working of an invention. He might have an invention for a capstan on board a ship; was he to be compelled to build a ship to show that capstan? He might have, as the late Mr. Longridge had, an invention for wire guns; was he to make a wire gun in order to justify his claim to the invention which was a mathematical deduction arrived at from long study? He could speak more feelingly, perhaps, on the question of mining and metallurgy, with which he had been conversant for the last twenty years. He had an invention which took out all metals, whatever their nature or number, from their ores. Was it necessary for him to own a mine in order to secure it? The power of invention might be defined as the prophecy of material progress. It came from above. It came to a variety of persons, many of them not educated, many thoroughly deficient in the germs of practical philosophy; but they were sent to forward the material progress of their country, and, incidentally, of the whole world; and their function was a most important one. The importance of this question was not only to the inventor or manufacturer, but mainly to the statesman. If the statesman were able by means of invention to see capital and labour always profitably employed, out of reduced taxation he could get increased returns, and it was his first business to see that the inventor was not only protected but as far as possible fostered. The greatest scandal that ever existed in regard to patents was in Great Britain. Any number of men could go on the same day to the Patent-office with the same invention, drawn up in precisely similar language, and each would get a patent, without any examination whatever. The evil to the inventor was the last thing to think of; he thought of the injury to the State. The capitalist would not invest unless he had a good title, and consequently capital and labour were not profitably employed. Look at the thousands of workmen and thousands and thousands of pounds employed in the cycle industry as an example

of the benefit to a country of a new industry being established. It was a question for the statesman, if capital and labour were not profitably employed, how he was to get his taxes to keep the people contented, and, above all, how he was to get votes. One of the first *raison d'être* of any Government was to protect property, and property without exception—the poor man's property as well as the rich man's, in fact the poor men's interest was the greatest, because there were so many more of them. With such views a very different idea would be held as to what industrial property meant. At the international Congress in Paris a definition was given of what industrial property rested upon, and it was put in very few words, that it was a common right, and that the law did not create it, but only regulated it. Starting from that basis they did not come to very wrong conclusions. They said a patent ought to last much longer, because if any property ought to be protected that which enriched the State ought. On that view the statesman would say—how shall I obtain the greatest number of votes, by side issues, or by doing that which is evidently for the benefit of the nation? The one was ephemeral and did not last; the other way gave permanent credit to the Government which adopted it, and it could increase its army and navy as required, because it knew how to do it. By the other plan, unfortunately the question was how not to do it. He could not speak too strongly on the subject of congresses such as Mr. Iselin had spoken of, but to think you would ever get all men to agree in one view was to ask too much of human nature. It would be a great thing if they could get people to see that a Patent-law was not a monopoly at all, and had nothing to do with monopoly. It was simply permission to do a thing under the obligation of payment to the man who enabled you to do it. When compulsory licenses were introduced it was impossible to justify the idea of monopoly, not that he thought them a good thing, nor apparently did the public, for they did not resort to them and very few were in the records. In the United States there were examinations, but what were they? You had a couple of patents thrown at your head as anticipations; you examined them and found not one word about your invention at all. You sent back a mild remonstrance to that effect, and perhaps ultimately they put through your patent after two years delay. Their examination did not give any authority to the patent, and no examination could. In our Patent-office there were no examiners at good salaries, whose principal merit was that they did not examine. There might be great benefit from discussions and congresses in bringing about a consensus of opinion, but he longed to see the day when a statesman should arise who could understand the importance of having a good patent-law.

Mr. S. BROMHEAD said the examination of patents in Germany was conducted with very great stringency,

and German ideas as to novelty did not accord with those current in any other country. The German Government seem to have adopted a military view of inventions, and to regard those which came from abroad as an invasion by a foreign foe. Such was his experience as a patent agent. You put in your application, and were immediately met with a reference to three or four other patents, and told there was no novelty in yours. When you answered that objection, you were met with another batch, and afterwards with a third or fourth, many of them having no reference whatever to the invention you sought to protect. They had also in Germany another system which they called an *Musterschut*, a kind of minor patent, under which you lodged a model and got protection for a certain time without any examination at all. It was not of much value, but you got a certain amount of protection and took your chance of whether it was good or bad. Admiral Selwyn objected to a number of specifications being lodged on the same day and accepted without examination, but he believed it was the practice to inform an applicant if there was an anticipation known to the office. Compulsory working was a serious objection in foreign countries. He had a little safety lamp which sold for 1s. The inventor had to work the patent in Austria, and they sent over patterns, and it cost about £4 10s., in order to satisfy the law, to make the article which in this country was made for 1s. It would be very beneficial if there were more accord between the ideas of different countries on these matters, and he hoped something in that direction would result from the congress which had been spoken of. He also thought that any country exacting fees from patentees, which paid the expenses of the office and left a large surplus, ought to give premiums to poor inventors, and assist them to bring out valuable inventions. A man who brought out a new industry did more for his country than one who managed to gain an important victory.

Mr. FRANK SAFFORD said he should like to emphasize what had fallen from Mr. Siemens with regard to the Merchandise Marks Act. The provision as to the country of origin showed the danger of tinkering in Parliament a Bill carefully drafted. That provision was introduced in the Customs portion of the Bill in Committee, and if it had been left as it was drawn by the promoters it would simply have forbidden fraudulent descriptions. It was introduced by a certain section who were anxious to protect the trader of this country, but it had tended to do him an injury. Mr. Iselin suggested that the present Act did not reach regional appellations which were intended to be reached by the international arrangements of 1891, but he could hardly agree with him there; if there were any false description it certainly came within the Act. He understood it had been held that the use of the term "port" by itself indicated that the wine came from Oporto, and if it did not the place of origin had to be specified.

The CHAIRMAN said in 1882 the Society of Arts undertook to prepare a Patent Bill which, he need hardly say, did not pass, the Government preferring to carry a measure of their own. He still thought the Society's Bill was the better of the two, but the Bill which was passed was a great improvement on that which existed before. With respect to preliminary examinations, the figures given by Mr. Abel were very striking, showing that where there was strict examination the patent was no more valuable than where there was none at all. Before making an absolute comparison, however, one would require to know whether the grounds for rejection were in all cases identical. Before the Society's Bill was drafted many meetings were held, and they consulted all the leading men of the day, and he believed he was right in saying that their unanimous judgment was that a preliminary examination into utility and novelty was undesirable, certainly so as regarded utility. It was made quite clear that many notoriously useful inventions, such as the fish-joint for railways, would have been condemned on the score of utility if there had been an examination. As to novelty he might repeat what had often been said in that room, that when Sir William Siemens applied in Germany for a patent for his regenerative furnace, he was told it was not new, because in the days of the Crusades hot bricks were used for the purpose of storing and conveying heat. With regard to putting names on goods as an indication of quality, though not the names of the maker, he happened to know that billiard cues, bearing the name of a celebrated billiard player as being—not made—but approved by him, were sold for 5s. more than similar cues without such mark. It had been remarked that there was no risk of property being endangered. He was not so sure of that. There was an institution, of which he was a member, called the Liberty and Property Defence League, and as he had often said the very fact of there being a league with such a title was evidence that something was wrong. He was once asked to return thanks after dinner for the Houses of Parliament, and he did not at all like the job, because he had such fear of that potent body. He never came out of his door in Great George-street and looked up and saw the lamp burning on the clock-tower without asking himself whose liberty of contract was being interfered with, or whose property was being taken away. There was an absolute destruction of what in his young days used to be looked upon as property. A dear friend of his—now dead—a celebrated engineer, told him that he kept all his investments out of England, as there was no place in which property was so unsafe. With regard to property in inventions, it was entirely to the interest of the community that such property should be recognised. As Sir William Siemens used to say, if an invention were lying in the gutter, it would pay the community to make it over as a property to someone who would foster it, and promote its exercise;

for without an owner, you did not get that promotion. It was to his mind perfectly clear that unless property in inventions had been recognised, ages might be passed before we reached the condition of things we now enjoyed. He concluded by moving a vote of thanks to Mr. Iselin for his paper.

The vote of thanks having been carried,

Mr. ISELIN, in reply, said he did not defend the compulsory working law, and hoped it would be the task of the association to which he had referred to get it abrogated where it existed. With regard to marks of origin on wine, he did not think Mr. Safford quite appreciated the point. It was provided by the Madrid arrangement that regional appellations connected with the products of the vine should in no case be considered generic designations—in other words that no one outside the districts to which those names belonged should be entitled to make use of them. It was not, therefore, open to any one in Australia or California to call his wine Burgundy though he prefixed the name Australia or California, or anything else. Yet, Australian and California Burgundy were advertised and sold in England and no one interfered with those who did so. He said therefore that at least it seemed doubtful whether our law carried out the provisions of the treaty. With regard to the point raised by Mr. Siemens on the Merchandise Marks Act, he had not expressed an opinion himself; he merely called attention to the fact that while many people said this law was unjust and unreasonable, those same people recommended that all possible means should be taken to induce other nations to introduce the same law. This seemed to him an inconsistency, and at any rate the subject was worth discussing.

Miscellaneous.

SUGAR AND WINE PRODUCTION IN PERU.

Among the agricultural products of Peru, cane sugar certainly takes the first place. The cultivation of the sugar cane dates back to the earliest period of the Spanish rule. The first canes imported came from Mexico, and were planted in the valley of the Huanuco, and the cane-growing district gradually spread until it extended over the department of Piura then it gained the littoral, and, finally, cane-growing became universal throughout the country. At the beginning only slaves were employed, and during the War of Independence the sugar industry suffered very considerably, owing to the falling off of this labour. Towards the middle of the present century an impetus was given to the industry by the introduction into the country of numerous Chinese colonists, and the plant

s were again vigorously cultivated. Judging from istics of exports, it would appear that the sugar istry is in a fairly prosperous condition, for it is nd that while the exports amounted to 44,700 tons 1885, they exceeded 75,000 tons in 1895. M. jandro, in an interesting study of this question ch has recently appeared, gives the following ticulars respecting the annual production of the icipal centres of cultivation:—Department of ia, 31,000 tons; La Libertad, 23,000 tons; nbayeque, 10,000 tons; Huanuco and other artments, 11,000 tons; total, 75,000 tons. If, ependently of the local consumption, the exports 1895 amounted to 75,000 tons, it is evident that production is greatly increasing. In certain dists, particularly in Montana, the sugar cane is culti- ed exclusively for the distillation of “tafia,” a spirit tilled from molasses. The introduction of the vine es from 1555, but it is only during the last 25 rs that viticulture has commenced to attain any y great importance. In the valley of Moquegua re are about 5,000 acres under vines, producing ually 385,000 gallons of wine and 550,000 gallons brandy. The valley of Chinchá (department of ancavelica) is still more important from a viti- tural point of view, and produces 990,000 gallons wine. In the department of Ica, the production of ndy has been replaced by that of wine, the yield of latter being about 550,000 gallons annually. At hort distance from Arequipa, in the valleys of or and Mages, vineyards have been very success- ily established, and these have already produced 000 gallons of wine and 176,000 gallons of brandy. e valleys of Locumba Cinto, Mirabe and Ilabaya, the department of Tacna, yield 88,000 gallons of ie, and are celebrated for their brandy, of which y produce 66,000 gallons. From the south the tivation of the vine has extended to the north. Magdalena, in the department of Lima, red wines good quality are produced, and the yield is about 000 gallons. Notwithstanding the low price of ie, the industry is considered a very lucrative one. e the south, white wines are produced as well as red ies; but the consumption of the latter is much ater. The red wines resemble Macon more than rdeaux, they have also a certain analogy with the ie of the north of Spain, known as “chacoli.” The ie wines resemble the Andalusian “Manzanilla,” ile the Belgian Consul at Lima says that there are n some of the white wines which, after being kept eral years in bottle, are highly appreciated, and are a good sherry flavour. As table wines, the Peruvian duct suffers under the disadvantage of being con- cerned too heady. Up to the present, the annual ort does not exceed 110,000 gallons, which are istributed in the neighbouring countries.

SWEDISH IRON AND STEEL.

Mr. A. G. Ljungberg, of Falun, Sweden, com- municates to the *Iron and Coal Trades Review*

the following particulars of Swedish production and exports:—

The Swedish ironmasters held their quarterly meeting in Orebro, the 27th ult., and their reports show that the production of iron and steel during 1896 and 1897 has been as follows:—

	Jan. 1 to Dec. 31, 1896. Metric tons.	Jan. 1 to Dec. 31, 1897. Metric tons.
Pig-iron.....	488,400	533,800
Charcoal-iron blooms..	185,500	189,000
Bessemer-steel ingots..	115,300	107,500
Siemens-Martin ingots	135,300	160,800

The figures show an increased make in pig iron of 45,400 tons, in charcoal iron blooms of 3,500 tons, and in Siemens-Martin ingots of 25,500 tons, while there is a decrease of 7,800 tons in the output of Bessemer steel ingots.

The furnaces in blast or working during the last quarter, October-December, 1897, have been as under:—

Blast furnaces	111
Charcoal hearths	292
Bessemer converters	27
Siemens-Martin furnaces	38

The export of iron and steel of all kinds for 1897 amounted to 274,900 tons, or 26,500 tons less than the export for 1896.

The home consumption throughout the year has been very good, and fully balanced the reduction in export; consequently 1897 has been a fairly satisfactory year for the Swedish Iron and steel manu- facturers.

TELEPHONES IN FRANCE.

The *Economiste Français*, in giving some particulars as to the extension of the telephone system in France, states that there are at present 112 towns, with a population of 6,000,000, which have 18,191 subscribers, half of whom are in Paris. It is not, however, in Paris that there are the most subscribers in proportion to inhabitants, for, at Cannes, the proportion is 1 to 120; 1 in 198 at Fourmies; 1 in 215 at Mentone, and 1 in 222 at Tourcoing, as against 1 in 253 in Paris. The article further shows how little the telephone is used by comparison with neighbouring countries like Germany and Switzerland, for, while the number of “communications” in France in 1896 was only 74,000,000, the total for Germany, excluding Bavaria and Wurtemberg, was over 424,000,000. Switzerland, with a population barely the tenth of France, had at the end of 1896 over 1,000 miles of telephone lines, with 29,533 subscribers, and about 150,000,000 communications. While the cost of a telephone in Switzerland is more than covered by the receipts, the contrary is the case in France, though the subscription

price is much higher than in any of the other countries, being as much as £16 13s. 4d. per annum in Paris, and from £8 6s. 8d. to £12 10s. in provincial towns, to say nothing of each subscriber having to contribute towards getting connected with the system. In Switzerland, in addition to the charge of getting an instrument put in and connected, the charge is £1 13s. 4d., and one halfpenny for each conversation of three minutes' duration.

POST OFFICE ELECTRIC MAIL VAN.

The motor mechanism of the new electric mail van which the Post Office authorities have been successfully working for some time between the General Post Office and Paddington differs in one or two essential details from that used by the makers on the electric cabs. It has been found desirable to replace the four-pole type Johnson-Lundell motor by one of the two-pole iron-clad pattern, in which the field winding surrounds the armature. This type of motor has been found more efficient than the former. There are two armature windings, two commutators, and two series field windings on each motor, says the *Electrician*. The brushes are of carbon, fed end-on to the commutator by a simple flat spring. The capacity of the motor is about $3\frac{1}{2}$ -horse power, and the mean working current about 30 ampères. On the armature spindle is a raw-hide pinion, having twenty teeth, which gears into the central wheel of the differential gear, this wheel being provided with sixty-two teeth. To provide for the different speeds of the driving wheels in turning curves, the countershaft is in two halves, each half being driven by the differential gear similar to that employed on the cabs. The other important change is the employment of a driving chain of the ordinary bicycle pattern in place of the laminated sprocket chain hitherto used. The cells used are of the E.P.S. Faure-King type, specially made for this purpose. Each cell is $6\frac{1}{4}$ in. square in plan, and 10 in. high, and contains eleven plates, which have a capacity of 172 ampère hours at a discharge rate of 30 ampères. Forty such cells are used, always in series, giving a pressure of about 80 volts. The cells are carried in a single tray, which is slung under the bottom of the van by four suspension links, supported from the body of the van by helical springs under compression. The total weight of the battery is about 13 cwt. The load carried sometimes amounts to one ton, and the maximum speed at which the mechanism is intended to drive the van is between ten and eleven miles an hour.—*Engineer*.

General Notes.

BULGARIAN COMMERCIAL MUSEUM.—The Bulgarian Ministry of Commerce and Industry propose to

open, during the present month, a Commercial and Industrial Museum, accessible to the public. The museum has been established with the object of collecting specimens of all products of the industry of Bulgaria, and of making the public acquainted with the productions of their country. It will be situated in the same building as the Ministry itself.

INTERNATIONAL EXHIBITION OF HORTICULTURE AT GHENT.—The fourteenth International Horticultural Exhibition is to be held at Ghent from April 16 to April 24 next. This exhibition, which takes place every five years, is organised and managed by the Royal Society of Agriculture and Botany at Ghent. It is under the patronage of the King and Queen of Belgium, and is subsidised by the national, provincial, and municipal Governments. It is the 163rd exhibition of this local society. The invitation to take part is extended to amateurs, horticultural and botanical or horticultural societies of all countries. The exhibits are divided into 28 groups, consisting a total of 718 competitions; in each of these there are offered at least two prizes, and frequently three. The jury will be composed of well-known foreign horticulturists engaged or interested in horticultural pursuits.

BOILER EXPLOSIONS.—The Manchester Steam Users' Association has issued a series of rules for boiler attendants, signed by Mr. Charles E. Strome, chief engineer. The general direction is—"Tend your boilers with care and attention; accidents may thereby be prevented, expenses reduced, and the labour of firing lessened," and further directions refer to water level, blow-off cocks, lighting fires, smoke prevention, emptying boilers, overhauling, cleaning, and inspection. The warnings relate to manholes, safety valves, and low-water alarms, steam-stop valves, and steam pipes and collapsed furnaces. The general warnings are—"Don't overload the safety valves; don't tamper with them; don't let the water level sink out of sight; don't allow the gauge cocks to set false; don't open the steam-stop valves hurriedly; don't empty the boiler while the steam is up; don't use unknown scale solvents or compositions."

CHINESE WEIGHTS AND MEASURES.—According to the *North China Herald*, quoted in the *Board of Trade Journal*, no other people are more commercially advanced than the Chinese, but their standard of weight varies in any two places, and is never the same except by accident. No one knows what a "catty" is going to be in a new place, until he has investigated. What is true of the catty holds, necessarily, of its subdivisions, the tael or ounce. The cash shopmen, "bankers," know why this is so, and all those who are compelled to do business with them know that it is so, and they do not ask why. The *li*, or mile, is fluctuating as the catty, though the result is of much less consequence. The *chang*, or rod, like other units, is knowable only upon inquiry, and the same is true in a more flagrant degree of the foot. The carpenter's foot measurement is one thing, and the tailor's is quite another, and so on. One meets with

leged foot-rules that are about 18 inches long, and with the catties that openly expand so as to take in eight-and-twenty or more ounces. The *mor*, or *re*, fluctuates in the same way, from 240 to 360, up to 720 *pu*, or paces, themselves units of uncertain magnitude, and a man who lives on the edge of different districts may have his farm measured on two totally different scales, with a resulting confusion in the statistics involved.

THE LIBRARY.

The following books have been presented to the Library since the last announcement :—

Armstrong, Lord, C.B., F.R.S.—*Electric Movement in Air and Water*. (London : Smith, Elder, & Co., 1897.) Presented by the Author.

Bamber, M. Kelway.—*A Text-book on the Chemistry and Agriculture of Tea*. (Calcutta : Law Publishing Press, 1893.) Presented by the Author.

Benjamin, Park, Ph.D.—*The Intellectual Rise in Electricity : a History*. (London : Longmans, Green, & Co., 1895.) Presented by the Publishers.

Bolas, Thomas—*Glass Blowing and Working, for Amateurs, Experimentalists, and Technicians*. (London : Dawbarn and Ward, 1898.) Presented by the Author.

Constantine, E. G.—*Marine Engineers, and How to become One*. (Manchester : Technical Publishing Co., 1897.) Presented by the Author.

Daw, Albert W., and Zacharias W. Daw.—*The Mining of Rock in Mines, Quarries, Tunnels, etc.*

Part I. *The Principles of Rock-blasting and their general Application*. (London : E. and F. N. Spon & Co., 1897.) Presented by Z. W. Daw.

Dow, Wilson, and Stanton.—*Tea-producing Countries of India and Ceylon, showing the History and results of those Capitalised in Sterling*. (London : Southey and Co., 1897.) Presented by the Authors.

Imperial Institute.—*Correspondence respecting the first and Second Quinquennial Grants from Indian Governments to the Imperial Institute, 1896*. Presented by Sir George Birdwood.

Lake, W. R.—*Patents for Inventions relating to Machine Guns and Automatic Breech-Mechanism*. (London, 1896.) Presented by Messrs. Haseltine, Lane, and Co.

London Chamber of Commerce Report *re* Cement and Mortar mixtures, with Evidence of Experts. (London, 1897.) Presented by the Chamber.

McGhie, James.—*A Short Treatise on Building Materials*. (Aberdeen : James Murray, 1891.) Presented by Mrs. Scorgie.

Ward, H. Snowden, and Catherine Weed Ward.—*Shakespeare's Town and Times*. (London : Dawbarn and Ward, Limited, 1896.) Presented by the Authors.

Warden-Stevens, F. J.—*Electrical Installations for Architects, Borough Surveyors, Civil Engineers, etc.* (London : P. A. Gilbert Wood, 1897.) Presented by the Author.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock :—

FEBRUARY 23.—“Children's Sight.” By R. BRUDENELL CARTER, F.R.C.S. Sir GEORGE KEKEWICH, K.C.B., will preside.

MARCH 2.—“Kites : their Theory and Practice.” By Captain B. F. S. BADEN-POWELL. Professor W. GRYLLS ADAMS, F.R.S., will preside.

MARCH 9.—“Linde's Method of Producing Extreme Cold and Liquefying Air.” By Professor J. A. EWING, F.R.S.

MARCH 16.—“The Recent History of Paper-making.” By CLAYTON BEADLE.

MARCH 23.—“The Preparation of Meat Extracts.” By C. R. VALENTINE.

MARCH 30.—“Telegraphy Across Space.” By Professor SILVANUS P. THOMPSON, F.R.S. J. W. SWAN, F.R.S., will preside.

Dates to be hereafter announced :—

“Stage Mechanism.” By EDWIN O. SACHS.

“Water Gas and its Appliances.” By Professor VIVIAN LEWES.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock :—

MARCH 10.—“India and Sir Henry Maine.” By CHARLES LEWIS TUPPER, C.S.I. The Right Hon. Sir MOUNTSTUART ELPHINSTONE GRANT DUFF, G.C.S.I., F.R.S., will preside.

MARCH 31.—“The Earthquake in Assam.” By HENRY LUTTMAN-JOHNSON, I.C.S. The Right Hon. Sir HENRY FOWLER, G.C.S.I., M.P., will preside.

APRIL 21.—“The Rise, Progress, and Present Position of the Native Press of Western India.” By R. P. KARKARIA (of Bombay).

APRIL 28.—“India and Currency.” By Sir EDWARD SASSOON, Bart.

MAY 19.—“Chartered Companies and Colonisation.” By Sir ALFRED COMYNS LYALL, G.C.I.E., K.C.B., D.C.L. (Member of the Council of India).

The meeting of March 31 will be held at the Imperial Institute ; those of March 10, April 21, April 28, and May 19 at the Society of Arts.

FOREIGN AND COLONIAL SECTION.

Tuesday Afternoons, at 4.30 o'clock :—

MARCH 15.—“The West Indies and Sugar Bounties.” By NEVILLE LUBBOCK.

Date to be hereafter announced :—

“The African : what he is, and what he is capable of becoming.” By the Rev. GODFREY DALE (Universities Mission to Central Africa).

APPLIED ART SECTION.

Tuesday Evenings, at Eight o'clock:—

FEBRUARY 22.—"The Regalia of England." By CYRIL DAVENPORT. SIR GEORGE BIRDWOOD, K.C.I.E., C.S.I., will preside.

MARCH 8.—"The Making of a Stained Glass Window." By LEWIS FOREMAN DAY. WALTER CRANE will preside.

MARCH 29.—"English Art in Illuminated MSS." By Sir EDWARD MAUNDE THOMPSON, K.C.B.

APRIL 26.—"The Importance of Craftmanship." By Sir WILLIAM BLAKE RICHMOND, R.A., K.C.B.

MAY 10.—"The Art of William Morris." By F. S. ELLIS.

MAY 17.—"Practical Points in Italian Majolica Painting." By WILLIAM BURTON, F.C.S.

CANTOR LECTURES.

Monday Evenings, at Eight o'clock:—

HUGH STANNUS, "The Principles of Design in Form." Four Lectures.

LECTURE II.—FEBRUARY 21.—Gradation, Proportion, Scale, &c.

LECTURE III.—FEBRUARY 28.—Repetition, Alternation, Axiality, &c.

LECTURE IV.—MARCH 7.—Simplicity, Reticence, Unity, &c.

PROF. W. NOEL HARTLEY, F.R.S., "The Thermo-Chemistry of the Bessemer Process." Three Lectures.

March 14, 21, 28.

DR. D. MORRIS, C.M.G., "India Rubber." Two Lectures.

April 18, 25.

PROF. CARUS WILSON, "Electric Traction." Four Lectures.

May 2, 9, 16, 23.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEB. 21... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Hugh Stannus, "The Principles of Design in Form." (Lecture II.)

Sanitary Institute, 74A, Margaret-street, W., 8 p.m. Dr. Louis Parkes, "Blots in our System of Sanitary Administration."

Imperial Institute, South Kensington, 8½ p.m. Colonel C. M. Watson, "The Nile and its Tributaries."

Surveyors, Savoy-street, W.C., 8 p.m. Mr. T. W. Wheeler, "Legal Liability for Professional Opinion."

British Architects, 9, Conduit-street, W., 8 p.m. Mr. J. Tavenor Perry, "The Mediæval Campanili of Rome."

Camera Club, Charing-cross-road, W.C., 8½ p.m. Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 8, Adelphi-terrace, W.C., 4½ p.m. Dr. Kidd, "Purpose in Nature."

London Institution, Finsbury-circus, E.C., 5 p.m. Sir Martin Conway, "The First Crossing of Spitzbergen."

TUESDAY, FEB. 22... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Applied Art Section.) Mr. Cyril Davenport, "The Regalia of England." Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. Ray Lankester, "The Simplest Living Things." (Lecture VI.)

Medical and Chirurgical, 20, Hanover-square, 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Mr. Llewelyn B. Atkinson, "The Theory of Design, and Practical Working of Alternating Motors." 2. Mr. H. F. Parshall, "The Electric Tramway."

Photographic, 12, Hanover-square, W., 8 p.m. Mr. A. W. Isenthal, "Photographic Manipulation in Radiography."

Anthropological, 3, Hanover-square, W., 8½ p.m.

WEDNESDAY, FEB. 23... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. R. Brudenell Carter, "Children's Sight."

Geological, Burlington-house, W., 8 p.m. 1. Thomas Codrington, "Some Submerged Reefs and Valleys in South Wales, Devon, and Cornwall." 2. Mr. W. S. Gresley, "Some New Carboniferous Plants, and how they contributed to the formation of Coal Seams."

Japan Society, 20, Hanover-square, W., 8½ p.m. 1. Mr. Noel E. Buxton, "Mountaineering in Japan." 2. Mr. M. E. Fordham, "An Ascent of Fuji San in May."

United Service Institution, Whitehall, S.W., 3½ p.m. Mr. W. V. Herbert, "The Ethics of Warfare."

THURSDAY, FEB. 24... Royal, Burlington-house, W., 4½ p.m. Antiquaries, Burlington-house, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Mr. W. Law Bros, "Primitive Ireland."

Society for the Encouragement of Fine Arts, Conduit-street, W., 8 p.m. Mr. E. Doran, "Wells Cathedral."

Sanitary Institute, 74A, Margaret-street, W., 8 p.m. Dr. H. Manley, "British Sanitary Laws."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. J. P. Richter, "Some Italian Pictures at the National Gallery." (Lecture III.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Mr. G. Binswanger Byng, "The Manufacture of Lamps and other Apparatus for 200 Volts and Circuits."

Camera Club, Charing-cross-road, W.C., 8½ p.m. Lecture by Mr. Val. Prinsep, R.A.

FRIDAY, FEB. 25... Royal Institution, Albemarle-street, 8 p.m. Weekly Meeting. 9 p.m. Captain Abney, "Theory of Colour Vision applied to Modern Colour Photography."

Civil Engineers, 25, Great George-street, S.W., 8 p.m. (Students' Meeting.) Mr. C. E. Wilson, "The Problem of Train Resistance."

Clinical, 20, Hanover-square, W., 8½ p.m.

SATURDAY, FEB. 26... Physical Society (in the Chemical Lecture-room, Keate's-lane, Eton College), 4 p.m. The Rev. T. C. Porter will describe:—(i.) "A New Theory of Geysers," (ii.) "A New Method of viewing Newton's Rings," (iii.) "Experiment bearing on the Sensation of Light," (iv.) "Method of viewing Lantern Projections in Stereoscopic Relief," (v.) "Winter Observations on the Shadow of El Teide, with a New Method of measuring approximately the Diameter of the Earth," (vi.) "Temperature of the Water of Niagara."

Botanic, Inner Circle, Regent's-park, N.W., 3½ p.m. Royal Institution, Albemarle-street, W., 3 p.m.

William H. Hadow, "The Structure of Instrumental Music." (Lecture III.)

Journal of the Society of Arts.

No. 2,362. VOL. XLVI.

FRIDAY, FEBRUARY 25, 1898.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****CANTOR LECTURES.**

Mr. HUGH STANNUS, F.R.I.B.A., delivered the second lecture of his course on "The Principles of Design in Form." on Monday evening, 21st inst.

The lectures will be printed in the *Journal* during the summer recess.

APPLIED ART SECTION.

Tuesday, February 22, 1898; Sir GEORGE BIRDWOOD, K.C.I.E., C.S.I., in the chair.

The paper read was "The Regalia of England," by Cyril Davenport.

The report of the meeting will be published in the next number of the *Journal*.

Proceedings of the Society.**INDIAN SECTION.**

Thursday, Feb. 17, 1898; EARL SPENCER, C.G., in the chair.

The SECRETARY of the Section read a letter from Mr. John Pollen, I.C.S., LL.D., who was Acting-collector of Bombay at the time the plague first appeared, and who was at present laid up with influenza. He wrote:—"Had I been present I could certainly have liked to have borne testimony to the noble work (of which I was an eye-witness) done by Mrs. Birdwood in visiting the hospitals, and in helping the plague-stricken at the very height of the calamity. Although in feeble health herself, she took every opportunity of visiting the Arthur-road and other hospitals, and the presence and kindly sympathy and assistance of the wife of the Senior Member of Council did much to encourage the sisters, the nurses, and the

little band of devoted English ladies who were the first to hasten to the aid of the despairing and bewildered natives. Mrs. Birdwood's womanly kindness will never be forgotten in Bombay, for ('let the dark face have its due') natives are not ungrateful. On the whole, throughout this awful plague business, they have displayed, in spite of panic, a patience and docility worthy of all praise; and they are, I am convinced, truly and sincerely grateful to those who sympathised with them and strove to serve them, amongst whom Mr. and Mrs. Birdwood were (as they have always been) the foremost."

The CHAIRMAN said he did not propose to make anything like a speech, but perhaps he ought to give some explanation for occupying that position. He could not speak as an expert in Indian affairs, though it was quite true he visited his brother-in-law (Lord Sandhurst) in Bombay two years ago, but he was not one who thought that a globe trotter who paid a flying visit had any right to make authoritative statements about that important country. He should like, however, to say that in England we had a very heavy responsibility with regard to our great Indian Empire, and he could not help thinking that there had been rather a want of interest with regard to it. He was, therefore, glad to show that, at all events, though unconnected with India, he yet took a deep interest in it, and he was glad to see so large a meeting assembled to hear from Mr. Birdwood an account of this terrible plague. They had the greatest sympathy with the people of India in the calamity under which they had been placed, and had also a sincere admiration for the patriotic work done by all those who were concerned in trying to get rid of this terrible plague.

The paper read was—

THE PLAGUE IN BOMBAY.

By H. M. BIRDWOOD, C.S.I., M.A., LL.D.

CONTENTS.—Previous epidemics.—The specific cause of plague. Kitasato's Bacillus.—The disease defined. Its symptoms.—Invasion of the human body by the bacillus. Incubation of the disease.—Protection against invasion. Mons. Haffkine's prophylactic.—Treatment of plague cases.—Communication of the disease by infected persons and otherwise. "Local incubation." The means of diffusion.—Growth of plague in Bombay. Mortality during the epidemic of 1896-97.—Mortality in some previous epidemics.—Virulence of the disease at different times.—Virulence of some other epidemics.—Climatic conditions favourable to the growth of plague.—Local conditions.—Personal conditions. Susceptibility of different races.—Initiation of preventive and remedial measures by the Bombay Government.—Measures taken by the municipal authorities.—Deputation of Dr. Cleghorn to Bombay.—Plague hospitals.—Popular dread of hospitals.—Measures under Epidemic Diseases Act. General Gatacre's Committee.—Soldiers on plague duty.—Hospital nurses.—Inspection of passengers, &c.

It is not without some hesitation that I venture to address you on the subject of the recent visitation of plague in Bombay, for

there are various questions connected with plague epidemics which can be discussed with profit only by experts in science. But I have not been deterred by this consideration, for the subject can be approached from many points of view, and an account of some of those features and incidents of the plague which became generally known in Bombay during the epidemic of 1896-97, and of the methods adopted for its repression will not, I trust, be uninteresting. And if, to complete the narrative or to make it clearer, I find it necessary to refer to some technical details which could be better dealt with by a member of the medical profession, I shall, as to these, be careful to rely mainly on the recorded opinions of experts.

PREVIOUS EPIDEMICS.

Medical authorities are, I believe, agreed as to the identity in character of the "bubonic fever" of Bombay with the disease historically known as the plague, such, for instance, as the pestilence which prevailed in Lybia, Syria, and Egypt in the 3rd century before Christ, and in Alexandria at the beginning of the Christian era, and the "bubo plague" which invaded the Roman Empire in the 6th century after Christ and remained in Europe for a thousand years, and the "Black Death" of the 14th century, which started from Eastern Asia, and possibly also from a plague centre in India, and proceeding in a westerly direction to Asia Minor and the north coast of Africa, infected the whole continent of Europe and most of the adjacent islands, and visited Greenland also, destroying in Europe alone about 25,000,000 of human beings,—that is, about one-fourth of the population. Numerous epidemics of the same disease were widely spread in the 15th century, and seemed, during the greater part of the two following centuries, to have become firmly established on European soil, till towards the end of the 17th century they retreated slowly eastwards. The plague lingered, however, in the south-eastern corner of the Continent till 1841, and then, after a slight outbreak in some villages on the Volga in 1878-79, it "vanished completely" from Europe.*

The last epidemic of plague in England was in 1665, the year of the Great Plague of London; but sporadic cases were registered in London in most of the following years till 1679. The last great outbreak in France was in 1720.

In Africa, the disease never extended beyond the northern coast-belt.

Egypt was the starting point of numerous epidemics which have overrun that tract since the 6th century, just as Turkey was the point of departure in Europe for every inroad after the plague area had become narrower and the channels of diffusion clearer.* It is said that, although the plague has not unfrequently extended to Upper Egypt, it has always reached its limit in Assuan, never going higher than the first cataract and never entering Nubia. Epidemics of plague have been described by several writers as having occurred in Nubia, Dongola, Kordofan, and Khartoum, but have not really been identified with the plague.†

In Asia, epidemics were most frequent up to the year 1844, in Syria and Asia Minor. Since 1850, they have occurred in Persia, Arabia, and Mesopotamia. At one time, Persia was considered the eastern limit of the plague area in Asia, but this view is no longer possible.

I learn from Mr. William Foster, of the India Office, the accomplished Secretary of the Hakluyt Society, that Sir Thomas Roe's unpublished diary contains a reference to an epidemic of plague at Agra, which lasted for three months during the cold weather of 1616-17. Joseph Salbancke, in a letter to the East India Company, also unpublished, speaks of the same epidemic, from which 1,000 people sometimes died in a day.

Mr. Alexander Rogers has recently told us that the Emperor Jehangier's autobiography contains a reference to epidemics of plague which occurred at Agra in three successive years in the middle of the 17th century. The disease prevailed in the cold weather, and disappeared in the hot season.‡

In his report on the recent Bombay epidemic, Dr. Weir, Executive Health Officer of the Municipality, gives some interesting information about previous epidemics in the Deccan and Western India, including Bombay.

It appeared in the Emperor Aurungzebe's camp in 1684, and again in 1689; at Surat in 1684 and 1690; at Bassein in 1690; at Bulsar in 1691; at Tatta, in Sind, in 1696, when 30,000 people died of plague; and in Bombay, at intervals, from 1689 to 1702. The virulent form of plague, known in British Garhwal and Kumaon as *Gola*, or *Phatkya rog* or *Mahamari*, has probably existed in the hill tracts of India and China from time imme-

* Dr. August Hirsch's "Handbook;" translation by Dr. C. Creighton, vol 1, 498-500.

* Hirsch, vol 1, 502, 504.

† *Ib.* 506.

‡ *Indian Magazine and Review*, January, 1898.

morial.* It showed itself in 1823 at Kedar-math,† and in several villages above the snow line.‡ From 1834 to 1837, it became more widely diffused, and in 1837 it was alarmingly prevalent along the higher parts of the Pindar river.§ In 1846-47, it found its way to the sources of the Ramganga, and swept away nearly the whole population of a village at a height of 7,000 feet above the sea. It re-appeared at intervals at different places in Kumaon and Garhwal till 1894. In 1853, it descended to the plains of the Moradabad district, where it remained during the following year. In Central India, it was present from 1813 to 1821, and extended to Rajputana, the Rann of Kutch, certain towns in Guzerat, to Kathiawar and to Sindh, "where the mortality was great." In 1836, and again in 1837, it broke out at Pali, in Marwar, and spread to Jodhpore, Meywar, and Ajmere. The plague committed frightful ravages in Yunnan from 1871 to 1873, and was still prevalent there in 1879.|| The southern slopes of the Himalayas and the mountain valleys of Yunnan must now be regarded as endemic centres of plague.

THE SPECIFIC CAUSE OF THE DISEASE.

KITASATO'S BACILLUS.

At one time it was believed that the plague was due to poisonous exhalations from corpses, and this theory was supported by the French Commissioners, Lagasquie and Pariset, who studied the plague in Egypt in 1828; but it was shown by Dr. Hirsch, of Berlin, more than 16 years ago, to be untenable. He pointed out that, for the development of the disease and the formation of a plague-centre, there is always required the access of the *specific virus of plague*, and that these centres are co-extensive with the limits of the diffusion of the virus. "Where the virus comes not, no matter how unfavourable the hygienic conditions, there the immunity from the pestilence is complete." Dr. J. F. Payne, President of the Pathological Society of London, writing a few years later, in 1885, describes the plague as depending on the reception into the body of a specific organic contagion, which becomes multiplied therein. "Analogy," he says, "makes it very probable that the contagion is a living organism of the class Bacteria."¶ The result shows that here, as elsewhere in the realm of scientific discovery,—

"The golden guess

Is morning-star to the full round of truth."

* Dr. Hutcheson's "Note on Mahamari."

† Hutcheson. ‡ Hirsch. § Hutcheson. || Hirsch.

¶ *Encyc. Brit.*, vol. xix; Art. "Plague."

The world of science has accepted as conclusive the investigations conducted by Dr. Kitasato and Professor Aoyama, who were deputed by the enlightened Government of Japan to study the disease at Hongkong in 1894. The *Bacillus pestis* discovered by Kitasato is now universally recognised as the essential cause of the plague. It is classed in the vegetable kingdom under the *Bacteria*, which are among the simplest of living forms, and consist of a single cell, with a limiting membrane. They are found almost everywhere. Some of them are our best friends. Others are the causes of disease in the animal kingdom. The plague bacillus belongs to the group of parasites or disease-producing bacteria which find a home in the bodies of certain animals. It is a little less than $\frac{1}{25000}$ of an inch in breadth and about $\frac{1}{10000}$ of an inch in length. Its size, however, is not constant.* To adopt an illustration used by Dr. Woodhead, it would take about 500 millions of such organisms, laid side by side, to cover a postage stamp.† Insignificant, however, as it seems, this minute organism has been so deadly an enemy of the human race that popular as well as scientific interest cannot fail to be aroused in regard to it at the outset of any inquiry about the plague. There are questions regarding its manner of life—its individual life, whether on the ground, or in the air, or in the bodies of men,—and its social life,—in societies which cannot be numbered,—questions also as to the conditions which favour its growth and the development of its poisonous power, and as to its methods of attack and the supposed susceptibility to attack of different races and communities, and as to the best means of repelling its attacks, many of which must remain unanswered for the present and until the bacillus and its habits can be studied, not merely when it is captive in the laboratory, but when it is a free agent also. But we can, at all events, note some of the ascertained facts.

Dr. Kitasato has found bacilli in the blood, the swollen glands, and other internal organs of plague patients. He describes them as rods with rounded ends, which are readily stained by the ordinary aniline dyes, the poles being stained darker than the middle parts and presenting a capsule, sometimes well marked. They show little movement. They can be cultivated on suitable media; and, when thus

* *Lancet*, 1897, vol. i.

† *Minutes of Proceedings, Inst. C. E.*, vol. cxxx. Art. "Bacteriology."

growing in a "colony," they can be seen with the naked eye. When grown in beef tea, they make the medium cloudy; and on potatoes they look whitish-grey. Their growth is strong in blood serum at the normal heat of the body. They require oxygen for their growth*; and multiply by fission—that is, by a lengthening of the cell and its transverse subdivision into two or more cells. Each divided portion is a new plant, which repeats in a few hours the process to which it owes its own existence. Reproduction thus proceeds in a rapid geometrical progression. No spores have as yet been found in plague bacilli.

Through the courtesy of Dr. Arnott, late physician of St. George's Hospital, Bombay, and of Dr. Ferguson, of the Pathological Institute of Glasgow, I am able to exhibit some microscopic preparations of bacilli found in a human being, in a rat, and in mice, and also two magic-lantern slides of photographs of bacilli taken from an affected gland. One of the photographs is by Dr. Bitter, of Cairo, who was in Bombay last year. [Slides shown.]

Dr. Kitasato and Dr. Yersin have found that cultures of bacilli are destroyed in a few hours by a temperature of 136° Fahr., and in a few minutes by a temperature of 212° Fahr. Sir William Robinson says that "its great enemy is the sun."† According to Dr. James it is easily killed by direct sunlight, by heating to a temperature of 140° Fahr., by antiseptics and by weak acids, but it can withstand simple drying for five or six days.

"In suitable conditions," says Monsieur Haffkine, "the germs will multiply indefinitely. When the nutritious medium is exhausted, but the bacilli are protected from desiccation or invasion of other growth, they may remain alive for many months, possibly for years. In the ordinary conditions, when exposed to the vicissitudes of the open air, bacilli of plague captured by the bacteriologist die out very rapidly, in about a week at the utmost. Plague epidemics, however, often last for years." He adds that "when the germ is got hold of" it almost dies if the bacteriologist only looks at it. And again: "The germs may rise, like any other dust, in the air, but under these conditions, when surrounded by air and light, they get weakened rapidly and die. In any case, it is so when the bacteriologist keeps them under watch." It is probable that the germ is most actively poisonous "immediately

on leaving a diseased body or after an interval of a day or two." There may, however, be germs which require longer periods for acquiring full strength. "This is not known." At present it is supposed that the virulence of the microbe depends "on its previous passage through a susceptible animal or man." The probability of germs retaining their virulence for any length of time while in the air appears to Monsieur Haffkine to be remote. His opinion that the microbe, as scientifically studied in a test tube, "is somehow different from the complex phenomena which determine an epidemic" is, I believe, one that is shared by others who have lately been engaged in scientific research in Bombay.

In Italy, in the 17th century, it was believed that the poison of plague was smeared by certain foreigners on the doors and walls of houses. It was alleged that the walls and benches and even the bell-ropes of Milan Cathedral were thus anointed. The frequent appearance of a "yellowish-whitish" substance sprinkled on walls "as with a sponge," is attested by the personal observations of Ripamonti, as related by Manzoni, and caused the utmost popular excitement. Householders burnt the affected places with lighted straw.* "Patches and blotches of infection broke out upon the walls and houses, and when scraped off would reappear until the house was burnt down."† It is doubtful whether bacteriologists will admit that such appearances could have been natural colonies of plague germs.

Dr. Yersin once thought that he had traced plague bacilli in the soil, but I believe that he found afterwards that he had been mistaken. Bacilli have not, so far as I know, been actually found in the ground or in a free state in the air.

THE DISEASE DEFINED. ITS SYMPTOMS.

The term "bubonic fever," by which the plague was first designated in Bombay, has been objected to by Dr. Lyons, as another acute infectious disease, characterised by inflammatory swellings of certain glands, but entirely distinct from plague, has already been described as glandular fever. He prefers the word "plague," for it indicates that the disease is a "stroke." "The victim is struck down and dies. In malignant forms of fever, such as typhus, scarlet fever, small pox, and malaria, people are also struck down and die quickly;

* Dr. C. H. James's "Report on Plague."

† *Colonial Reports*, No. 148, "Hongkong," 1894.

* "I Promessi Sposi," Ch. 31; translation by Herbert Batty.

† "John Inglesant," Ch. 33.

but malignancy is exceptional in these diseases, while in plague it is the rule."*

The plague is defined by Dr. J. F. Payne as a specific febrile disease, transmissible from the sick to healthy persons, and accompanied usually by buboes and sometimes by carbuncles.† Dr. Arnott, in his recent address to the Medico-Chirurgical Society of Glasgow University, classifies plague cases, as observed in Bombay, under four heads: (1) mild cases, with buboes; (2) severe cases, with buboes; (3) pneumonic plague, with or without buboes; and (4) abdominal plague, resembling typhoid fever. "There are also mild cases—ambulant plague—which seldom come under treatment, but may spread the disease."‡

According to Dr. Payne, the mild plague sometimes precedes and sometimes follows severe epidemics, as on several occasions in Mesopotamia, from 1873 to 1878, and in Astrakan in 1877.

This form of the disease is, in Dr. Kitasato's opinion, dependent on the same bacillus as that which produces the severe form, "but in an attenuated or benign phase." In this opinion Dr. Cantlie concurs.§

The symptoms of severe plague, as observed in Bombay, vary with the precise type assumed by the disease. According to Dr. Childe, in the form with buboes, the attack is sudden, being often accompanied by rigor at first. Then fever comes on, with bad headache, vomiting, and frequently delirium. The temperature rises to 104° Fahr., or more. The respirations are increased and the pulse is rapid. The face of the patient assumes an anxious expression, and he feels a pain in the groin and under one arm. Later on, a mass of painful glands is seen on the tender spot. Formerly, no cases were diagnosed as plague unless there were external "buboes."||

Dr. Childe describes also the form without buboes, which resembles bronchitis or pneumonia, and is usually fatal within three or four days. The onset is sudden, with rigor, fever, headache, &c. Symptoms of bronchitis or pneumonia then appear, but the patient is much more ill and his fever is much higher than can be explained by the amount of lung disease present. The lymphatic glands are either normal or only slightly enlarged, and

there is no pain. This form of the disease is the "pneumonic plague."

Dr. Hojel has described some cases of the "abdominal type of plague," which, in their early stages, bear a very strong resemblance to enteric fever, the differential diagnosis being very difficult.*

Dr. Weir notices the desire to wander, which is sometimes a "strange and pathetic" symptom of the disease. A patient with a temperature of more than 100° suddenly leaves his house, and if he has any money, he drives to a railway station, with the intention of going to some place by rail; he cannot say why. Dr. Weir noticed this desire to wander in all classes, and it often precedes high fever and delirium.

During the epidemics of plague in the Middle Ages, certain black patches on the skin, known in England as "tokens," were considered to be sure precursors of death, and gave rise to the name, "Black Death."† No such symptoms were, I believe, observed in Bombay, and their absence suggests to Dr. Arnott the probability that typhus and other diseases may have been mixed up with the plague in those epidemics.

INVASION OF THE BODY BY THE BACILLUS. INCUBATION OF THE DISEASE.

According to the observations of Dr. Leumann, local inoculation through abrasions, however minute, such as cuts and scratches of the skin, has been the most common method of invasion in plague cases, especially among the poorer classes, who go about, for the most part, bare-footed, and with their arms and legs insufficiently covered.

The congestion and enlargement of the lymph glands nearest the point of inoculation indicates an attempt at local resistance. Where the organism attacked resists the micro-organism, the disease remains local; but where the power of resistance of the organism is lowered, or was, from the first, slight, "the bacilli become generalised throughout the body, reaching the blood either by the lymph channels, or, in some cases, by direct extension into the veins in or around the glands, and producing true septicæmia. Such cases are almost always, if not invariably, fatal."‡ In the pneumonic variety, described by Professor Childe, the bacilli may be either breathed into the lungs, as in "primary plague

* *Bombay Med. and Phys. Soc. Journ.*, vol. 1, pt. 5.

† *Encyc. Brit.*

‡ *Scottish Med. and Surg. Journ.*, Jan., 1898.

§ *Brit. Med. Journ.*, 1896, vol. 11, 1831.

|| *Bombay Med. and Phys. Soc. Journ.*, vol. 1, pt. 5.

* *Bombay Med. and Phys. Soc. Journ.*, vol. 1, pt. 5.

† Payne.

‡ *Bombay Med. and Phys. Soc. Journ.*, vol. 1, pt. 5.

pneumonia," or the plague may involve the lungs, among other organs, during the course of the septicæmic form, thus producing "secondary plague pneumonia."

And, thirdly, as Dr. Leumann observes, invasion by absorption from the alimentary canal "is quite a likely mode of invasion, and should not be forgotten as a possible one."

Dr. Herbert observes that, in the more fatal septicæmic type of plague, in which there are few, or no, obviously enlarged glands, the bacillus is found in large numbers in the blood; but in the ordinary bubonic type the blood is not the chief seat of the disease. The members of the Russian Plague Commission in Bombay, Professor Wysokowicz and Dr. Zabolotny, found that, in bubonic cases, the enlargement of the glands was mostly due to the presence of enormous numbers of bacteria.* In primary pneumonic plague, the sputum is full of bacilli. These facts show that the microbes multiply after they enter the body.

Observations in the hill tracts of Northern India favoured the conclusion that the period elapsing between the infection of the patient and the manifestation of plague symptoms is very short. Dr. Hutcheson says that the disease may prove fatal "within 24 to 48 hours after exposure to infection." The period of incubation was supposed at Hongkong to range from two and a half to six days; but in some cases to be as long as nine days.† In malignant epidemics, Dr. Payne says that the period may be shorter, and may be even reduced to less than a day. Generally a week's observation would show whether a suspected person is really infected or not. Dr. Choksy found that, in some exceptional cases, the patient's power of resistance and his general state of health prolonged the period to twelve days. For the purposes of the plague regulations prescribed by the Venice Sanitary Convention of March 19, 1897, the period of incubation is fixed at ten days.

PROTECTION AGAINST INVASION. MONS. HAFFKINE'S PROPHYLACTIC.

The question of protection against invasion is necessarily of the greatest practical importance. Monsieur Haffkine's prophylactic treatment by inoculation with a fluid serum, containing plague germs destroyed by heat and certain products resulting from the process of preparation, has been much in favour. Up to October last, 8,142 persons in Bombay and

6,601 elsewhere had voluntarily undergone this treatment. Of the 8,142 persons in Bombay, only 18 were attacked by the plague, and of these 18, only 2, who were already unwell at the time of inoculation, died. Of these persons, 5,535 belonged to the middle classes and 2,119 to the poorest class, whose condition rendered them susceptible to attack. The immunity afforded was, therefore, remarkable. In the town of Mora, 419 persons, living in the midst of a badly-affected population, were inoculated. Of these, 4 were attacked, but rapidly recovered. In lower Damaun, there were 6,033 persons who were not inoculated, of whom 1,482 or 24·5 per cent. died of plague. Of 2,197 who were inoculated only 36 or 1·6 per cent. died. Very favourable results were also noted at Lanaoli and Kirkee. Monsieur Haffkine has recorded, as the result of certain experiments in the House of Correction in Bombay, that an injection of the ordinary dose of the prophylactic was sufficient to effect protection, no repetition of the dose being necessary during an existing epidemic, but that the prophylactic is powerless to arrest symptoms of plague already started or developed within a few hours. It might probably, however, influence the disease in the incubation period in individuals affected three or four days previously. The time required for producing immunity is shorter than in any known protective treatment against other diseases, being less than one day; whereas in anti-cholera inoculation it is four days, in vaccination against small-pox seven days, in inoculation against anthrax twelve days, and against rabies fifteen days. In order to insure more lasting immunity, it is advisable, Monsieur Haffkine says, to apply repeated inoculations with doses larger than the ordinary dose. The reason, as explained by Dr. Herbert, why repeated doses have a cumulative effect is that the anti-plague inoculation is not, like vaccination, the introduction into the system of a living organism which multiplies locally for some days in order to produce symptoms, or, if the person be resistant, "does not take," but is a "certain dose of chemical substances already elaborated in the culture vessel." And it would be "as unreasonable," he observes, "to expect a second dose of these substances to produce no symptoms as to expect a person to be proof against alcoholic intoxication after once drinking a glass of whiskey." The evidence that has now been collected shows that the person inoculated is apparently "rendered so resistant to the plague

* *Bombay Med. and Phys. Soc. Journ.*, vol. 1, pt. 6.

† Lowson and Yersin.

organism that, when it is introduced into his system, it will fail to multiply or fail 'to take.' ”*

TREATMENT OF PLAGUE CASES.

As regards the medical treatment of plague cases it is not necessary that I should describe the various methods adopted. I ought, however, to state the opinion of so competent an authority as Dr. Arnott that no remedy has been discovered which can be relied on. Dr. Childe says that many methods have been tried in Bombay, “but none with certain success.” Some of the results of treatment with Monsieur Yersin's serum at the Parel Hospital, and with Professor Lustig's serum at the Arthur road Hospital, are given in Dr. Weir's report already referred to, and in Dr. Choksy's report on plague cases treated at the latter hospital, where a serum prepared by Professor Haffkine was also tried. Speaking from a very full experience, Dr. Choksy says that all that the means at our command can do is simply to tide the patients over the most critical period and to assist nature in recovering her original sway over the system. “In fact, the patients that left the hospital alive might more fitly be described as *recovered* than *cured*.”

COMMUNICATION OF THE PLAGUE BY INFECTED PERSONS, AND OTHERWISE. “LOCAL INCUBATION.” THE MEANS OF DIFFUSION.

For the past three centuries the question whether the plague is contagious or not has formed the subject of controversy. Dr. Hirsch regards the discussion as closed. There may be a difference of opinion, he says, as to the ways and conditions of communication, but not as to the fact itself. During the recent epidemic in Bombay opinions were mainly divided on the question whether the plague is highly infectious or only slightly infectious.

Dr. Ismael Jan Mahomed has expressed the opinion that the bacillus existed in Bombay in a passive form until it found conditions fit for its development.† It has been variously held that the bacillus was introduced with mouldy grain sent from Central India to Bombay for sale at a time when the famine had raised prices; or else by traders from Hongkong, or else by wandering mendicants from Garhwal; but nothing is really known as to the time and manner of importation. During the last few weeks, I have heard of two cases which were

treated by Dr. Kay, in the Byculla Infirmary of the Great Indian Peninsula Railway Company, so early as in February or March, 1896. They were not recognised at the time as plague; but in the light of later experience, Dr. Kay has no doubt whatever that they were cases of bubonic plague. Both the patients recovered, but other cases occurred among the Company's servants in June and July, 1896, which were fatal. Whether the germs of plague had been long lying dormant in the soil, or were actually introduced in March or February, 1896, or earlier, there can be no doubt that the disease was present, though not as an epidemic, for several months before its real character was known or even suspected. When, however, the epidemic was once established in Bombay, and large numbers of the inhabitants fled to distant towns and villages, they undoubtedly took the plague with them. Through the kindness of Surgeon-General Pinkerton, I am able to place on the table a map prepared by Dr. Grayfoot, which illustrates the spread of the disease in the Bombay Presidency up to the 1st November, 1897.

Several cases are well known in Bombay in which medical officers and nurses who have attended plague patients have themselves been attacked by plague. Cases have also occurred where the people of certain districts have apparently prevented the intrusion of plague from infected areas by simply keeping out all strangers. This was notably the case in the Pardi taluka.

Dr. Henderson again notes that, at every place in Sind where the plague has become epidemic, it has been preceded by imported cases.

On the other hand, some authorities have expressed a guarded opinion. Dr. Street thinks that patients under proper conditions are almost harmless, but that a sick person in a dark, unventilated house disseminates the disease in some way to the inmates. According to Professor Childe, attendants on a patient do not easily catch the disease, but they should be careful to wash after being with him. Early in 1897, the opinion was formally recorded by Dr. Cleghorn, Director-General of the Indian Medical Department, the late Dr. Henry Cook, Surgeon-General with the Bombay Government, Dr. Arnott, and other prominent members of the medical profession, that the disease was, “under certain conditions, only slightly contagious or infectious,” and that

* *Bombay Med. and Phys. Soc. Journ.*, vol. 1, pt. 2.

† *Bombay Med. and Phys. Soc. Journ.*, vol. 1, pt. 3.

"its incidence was greatly due to local conditions." Dr. Cleghorn describes the insanitary state of some of the Bombay "chawls," or tenements, containing from 500 to 1,000 inhabitants each, and thought that, if the plague had been highly contagious, the plague mortality would have been much greater. A visit to Karachi confirmed the conclusions he had arrived at in Bombay.

Mr. Hankin also describes an incident which may perhaps be contrasted with that already noticed in reference to the Pardi villages. The people of Worli, a fishing village a few miles to the north of the more thickly inhabited parts of Bombay, refused to allow any strangers to enter it. Here, then, was "a chance," Mr. Hankin says, "for a sanitary cordon to be successful, if anywhere. The plague, however, broke out suddenly in the village with appalling virulence." Most of the villagers then encamped in the fields, taking with them their bedding and household utensils. They came back every day to fetch supplies of grain from their houses; but, after camping out, they remained free from the disease. If the plague germs were either air-borne or earth-borne, or carried by rats or other ground animals, it can be understood why the cordon was not effectual. The Government of India held that the Worli incident supported the view that the plague is best combated by the evacuation of infected localities. It will be remembered that De Foe describes an exactly opposite procedure. In the great plague of London, houses were shut up when the plague appeared in them, and the inmates were not allowed to leave them, and the results were terribly fatal.

It is also a curious fact, noted by Sir William Robinson, that, notwithstanding the frequent communication between Hongkong and Macao, and the immigration into Macao of thousands from Hongkong, in May, 1894, when the plague was raging in Hongkong, not a single case of plague occurred at Macao.*

Again, in March, 1897, some cases occurred in the health camps at Karachi among persons who had been living there for more than 10 days; that is, longer than the ordinary period of incubation. There was no apparent communication of the disease by infected persons in these cases.

And, again, a Hindu family lost three of its members from plague in Bombay and the six survivors went to Katiana, in the Junagadh

State. Four of them died there in a few days, and the two who then survived left the house they were in, but returned after several weeks. There was nothing to suggest infection during their absence. On their return, however, they both fell ill and one died. The inference was that the house had become infected by the four persons who had died in it and that the poison clung to the house.

Dr. J. F. Payne suggests the following considerations, which seem relevant to the question at issue. There are some places where the plague is endemic, or "at home." In others it is imported. Where it is endemic, the poison is either kept in existence as a pure contagious disease, like small-pox,—by transmission from one plague case to another,—or else it may subsist outside the human body in soil, or water, or otherwise, as a miasmatic disease, like ague. Further researches may show whether the plague is both contagious and miasmatic. In Northern India, the disease seems to depend on a poison in the soil, as it returns in after years to the same spot, appearing in many villages simultaneously, and causing the death of ground animals. This is also observed in China. The plague may, therefore, be like anthrax or steppe murrain, both miasmatic and contagious, and may be carried by contagion to a distant place, and then be established in the soil for a longer or shorter period, according as conditions may be favourable. The adoption of this hypothesis would "remove many difficulties attending the explanation of plague epidemics."

Professor Childe is able, from recent observations, to express the belief that both parties are right,—according to the type of plague under consideration. "In many cases," he says, "the ordinary bubonic form of plague is not particularly infectious, and every one has seen that attendants on such cases, both in hospitals and private houses, do not readily take the disease;" nor, if care be used in the sick room, is the patient likely to convey the disease. With the pneumonic form of plague, "the conditions are quite different; for here the patient is freely coughing up and scattering around him what is practically a virulent pure culture of the plague bacillus." This form is highly infectious. Many of these cases, moreover, were not, at first, recognised as plague at all, so that the usual disinfection was not carried out. Pneumonic cases have thus had a large share in spreading the disease. Dr. Childe thinks it probable that the "Black Death" was really a severe type of the plague

* *Blue-book*, "Hongkong," C. 7534; 1894.

pneumonia. According to the Chroniclers, both medical and non-medical, the spitting of blood was one of the commonest phenomena in the course of that disease.* The bubonic and pneumonic forms of the disease were both recognised by the natives of Guzerat in 1820,† and Dr. Hirsch has no doubt as to the identity of the fatal Pali plague of 1836 (of which, according to Forbes,‡ expectoration of blood was a symptom) with the "Black Death" of the 14th century.

Dr. Henderson thinks that, in cases of importation of plague by infected persons, the germ requires a period of "local incubation" before attaining its full virulence, and that the imported infection is not probably strong enough to infect men, but infects rats and through them the people of the country. The period of local incubation, he considers to be the time between the importation of a case and the infection of the rats. Human agency, according to this view, would be the means of importation, and rats the disseminating agent. The Plague Commissioners, Drs. Reade and Lowson, also believed that rats convey the disease from place to place.

Dr. Weir has pointed out, however, that the death of rats is not the first phenomenon. It is preceded by a migration of rats, urged possibly by the instinct of safety, and Mr. Logan, the late Collector of Thana, in his report on the measures taken in that district, has described the "Rat's Progress" from south to north, through successive quarters of the town of Bandora and to villages beyond the limits of the town, which were not infected till the rats brought the plague. Mr. Snow, the Municipal Commissioner of Bombay, in his able report on the epidemic of 1896-97, observes that the presence of rats probably nullifies to an enormous extent the advantages to be derived from ordinary remedies, and points out that the plague in Bombay followed the migration of the rats, the course of which was generally from east to west and then northwards, up the sides and centre of the island.

Dr. Herbert thinks that an infected person probably transmits the plague to others indirectly by means of articles soiled by sputa and otherwise. In cases of primary plague pneumonia, however, the infection would reach the lungs through the air. Dr. Hughes, late Principal Medical Officer, Bombay District,

says that all the secretions of a plague patient, including the sweat, if not disinfected, are capable of infecting others, either directly or indirectly, through bedding, clothes or soil. In his opinion, the infection clings to the ground, and persons sleeping on cots have a better chance of escape than those sleeping on the ground. Dr. Bhalchandra Krishna, Consulting Physician of the Hindu Fever Hospital, says that cases of infection by means of the air, by direct contact, and through the soil have all come under his observation.

The fact was known to the physicians of the 16th century that even healthy persons may be the means of conveying the disease in their clothes or the pores of the skin, though they themselves may be unsusceptible or slow to succumb.*

A plague corpse may also be a focus of infection, especially if the deceased died out of hospital.†

With reference to the question whether a microbe can exist in an infectious condition for any time outside the body of a patient, it appears that a German investigator, working in Japan, has found that it can remain alive in linen for more than a month.‡ The two Goanese servants who were attacked with plague on arriving in London from Bombay were found to have unpacked and worn in London some clothing which they had brought with them. It is supposed that they were thus infected in London, as they were in good health throughout the voyage.

GROWTH OF PLAGUE IN BOMBAY. MORTALITY DURING THE EPIDEMIC OF 1896-97.

It will be convenient if we now consider the mortality returns for Bombay during the epidemic of 1896-97. It would only tend to confusion if I gave details of the returns for places outside Bombay; but I propose to compare the figures for Bombay itself with those of some other epidemics, as such a comparison may perhaps help us to appreciate some of the factors or conditions which favour the growth, duration and cessation of epidemics.

The first of the charts now on the screen shows the average daily mortality from all causes in Bombay for each week from May 19, 1896, to June 1, 1897, in contrast with the average daily mortality for the corresponding weeks in the preceding five years.

* Hirsch, p. 540.

† Gilder; quoted by Hirsch.

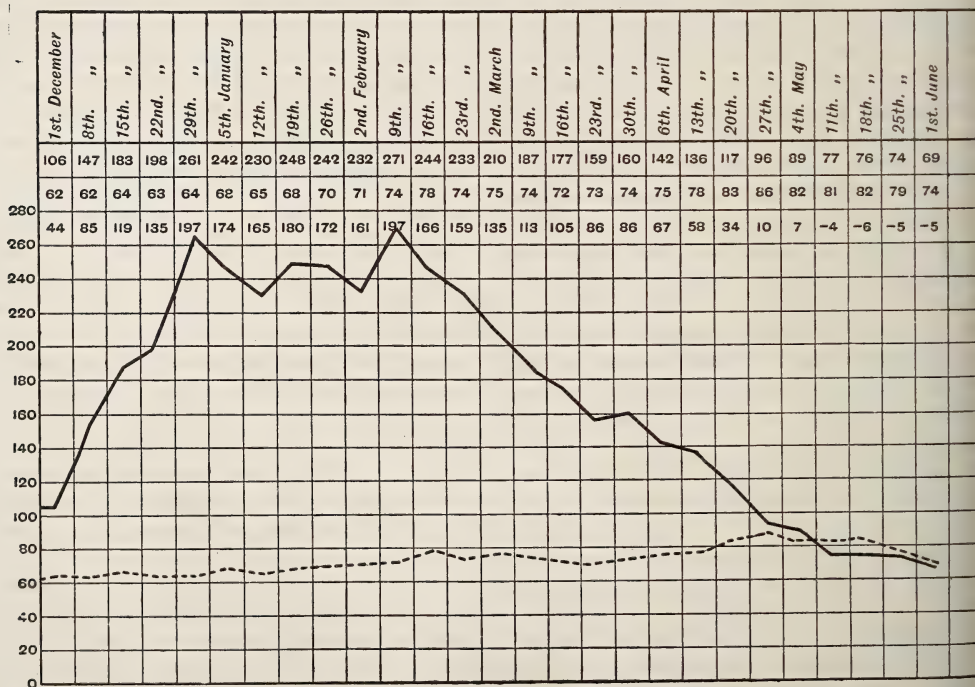
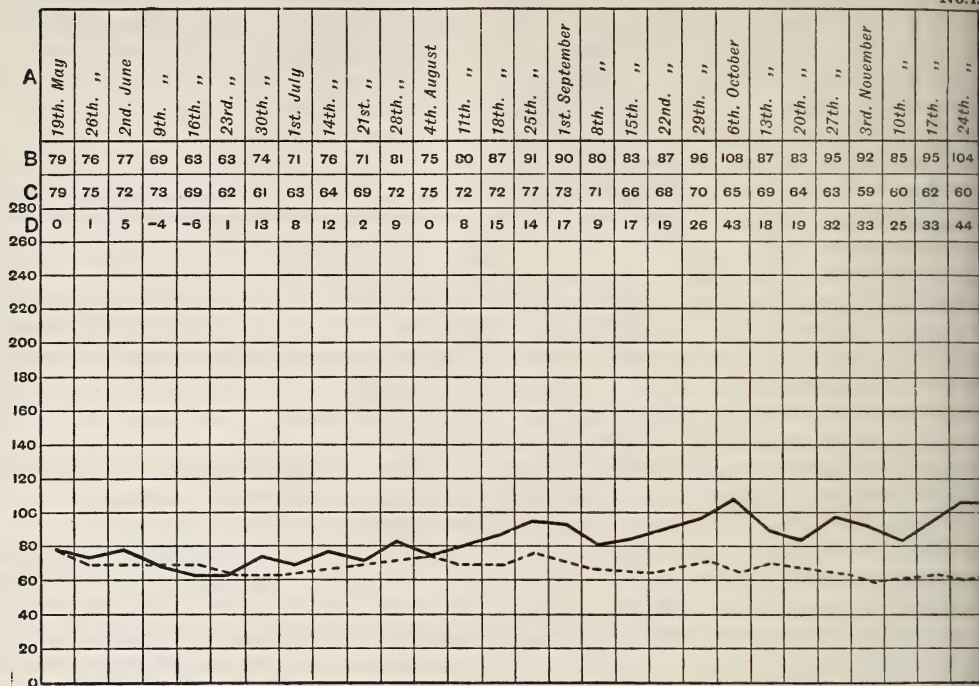
‡ "Bombay Transactions," vol. 11, pt. 15.

* Hirsch, p. 540.

† Reade and Lowson.

‡ *Bombay Med. and Phys. Soc. Journ.*, vol. 1, pt. 3.

No. I.



In this chart the figures in line B indicate the daily average mortality from all causes in each week, from May 19, 1896, to June 1, 1897: the figures in line C indicate the daily average mortality from all causes in each of the corresponding weeks in the preceding 5 years; and the figures in line D represent the excess of the daily averages for 1896-97 over the normal daily averages,—or a deficiency, as the case may be.

For the first six weeks the difference between the two sets of daily averages is scarcely perceptible. In the next thirteen weeks,—that is, up to September 22,—the excess of the mortality in 1896 is more marked, but in no week is the excess of the daily average more than 20. In the week ending September 29, it rose, however, to 26, and in the following week to 43. Then it went on rising, though with fluctuations, till, in the last week of December, 1896, the average daily mortality rose to 261, or 197 in excess of the average daily death-rate of 64 for that week. The greatest mortality recorded on any one day was on the 15th January, 1897, when there were 344 deaths; the number on the pre-

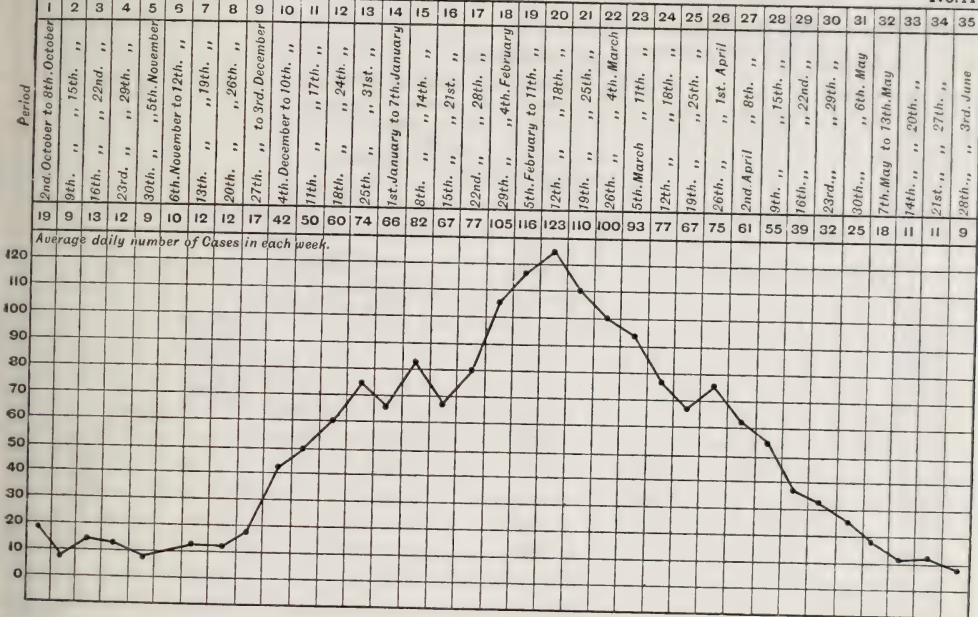
to April, 1897, when the variations from the normal mortality were most marked, the total mortality exceeded the average mortality by nearly 20,000 deaths.

The next chart shows the average daily number of plague cases,—whether fatal or not,—reported by the Municipal Health Department for each of the thirty-five weeks between October 2, 1896, and June 3, 1897.

Up to December 3 the daily average did not in any week exceed 19. Then it rose with a few fluctuations, till, in the week ending February 18, 1897, the number rose to 123 a day. Then there was a steady fall till, in the last week shown in the chart, it fell to 9. There were fewer cases in July than in June,

Number of Weeks.

No. 11.



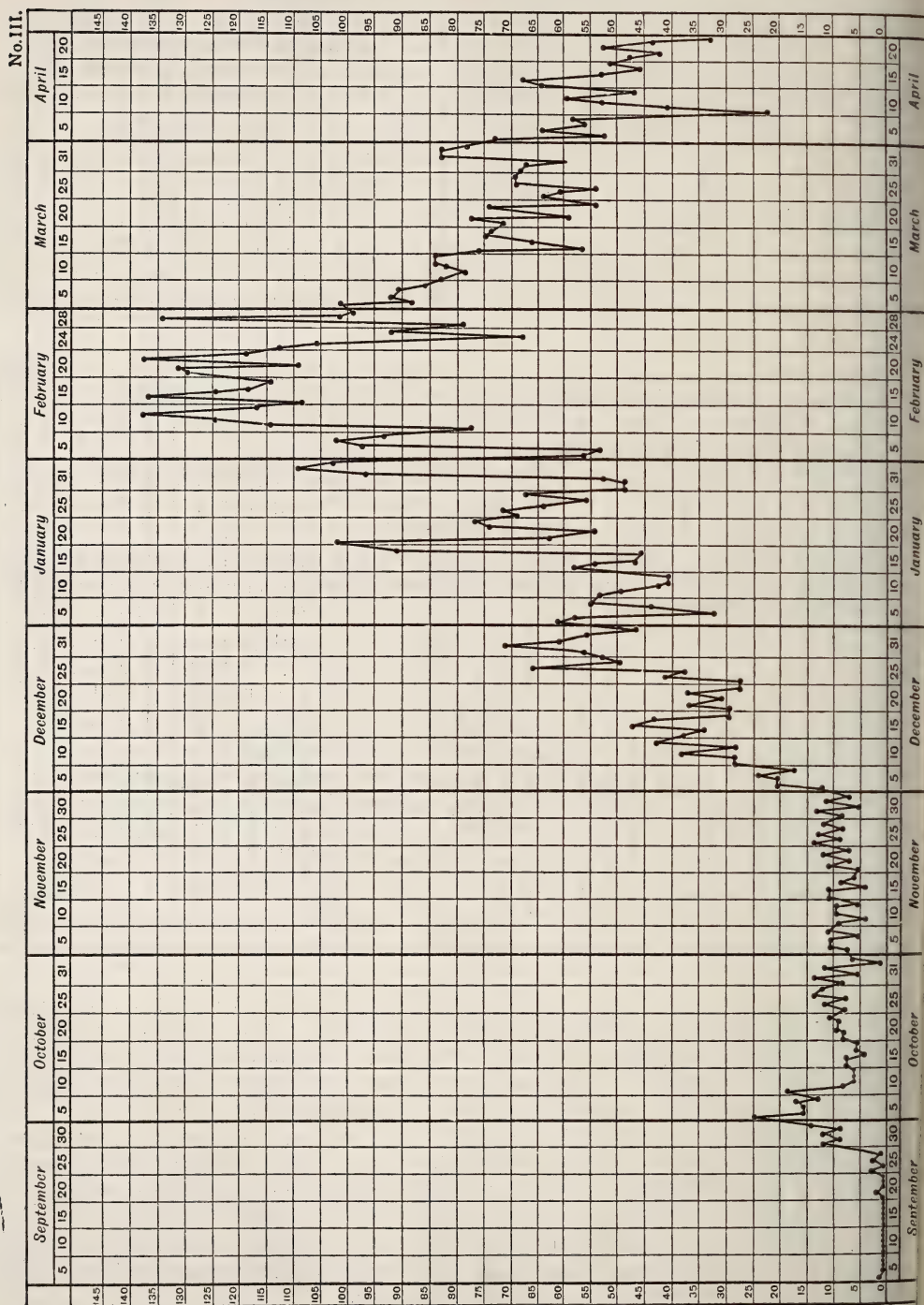
eding day having been 229; but these figures are not shown on this chart, which gives only averages. Then there was a sharp fall, with fluctuations, and in the week ending February 9, 1897, the average daily mortality reached 271, which again was 197 in excess of the daily average of 74 for that week. Then there was a steady fall till, in the week ending on April 20, the daily excess was only 34. In the following week it fell to 10, then to 7, and for the last four weeks shown in the chart the mortality due to all causes was, in 1897, below the normal mortality of those weeks.

During the seven months from October, 1896,

and by the middle of August the epidemic seemed to have spent its force. But towards the end of August there was, unhappily, a recrudescence, which was really the beginning of a fresh epidemic.

The first chart shows that the total mortality in Bombay from all causes was abnormally high in the seven months from October, 1896, to April, 1897. This second chart shows that the number of plague cases, that is, of seizures, as officially reported, amounted in this period to 11,837.

The third chart shows the course of plague mortality, as recorded by the Health Department, from September 1, 1896, to April 20, 1897.



COURSE OF PLAGUE MORTALITY, AS OFFICIALLY REGISTERED.

During the last fifteen days of September, the number of recorded deaths from plague rose from 1 per diem to 15. On October 1, 24 deaths were recorded. Then there was a fall, and the registered daily mortality did not on any day exceed 19 till the end of November. During December and January it rose suddenly, and on February 9, 138 deaths from plague were registered. After some sharp fluctuations, the same figure was reached on February 19. In the next four days it fell to 68, but rose again on February 26 to 135. Then it fell steadily, but with fluctuations, till April 6, when 23 deaths were reported. There were further fluctuations, but in the week ending May 3 (which is not shown on the chart) the daily death-rate was 21. In the next week it was 15. From May 11 to 28 it was 8, and from May 29 to June 17 it was 4. At this time the percentage of fatal cases to seizures was less than during the earlier stages of the epidemic. The virulence of the disease had declined, and there was a practical cessation of the first epidemic. In June, there were 98 deaths from plague, and in July 44.

In the seven months from October, 1896, to April, 1897, the total plague mortality, as officially recognised, amounted to 10,325; that is, to a little more than one half of the excess of the total mortality from all causes over the normal mortality. This figure cannot, however, be safely accepted as representing the actual plague mortality. It is admitted that, at first, the system of death registration was defective. It is not necessary here to describe the defects of that system, or the measures proposed for its improvement; but it is certain that many deaths from plague of one type or another were not recorded as such,—a circumstance which can partly be explained by such considerations as the following. In all plague epidemics, as observed by Dr. Payne, cases occur in which death takes place very rapidly, even within twenty-four hours, without the development of the special symptoms of the disease. As already pointed out, cases of the type without enlarged glands were not at first diagnosed as plague, and Dr. Hojel has indeed expressed the opinion that there was no concealment, except to a very small extent, on the part of the native community, but that up

February 1, 1897, there was a faulty diagnosis, many cases of real plague having been classed as cases of remittent fever, or as of some disease of the respiratory system. It was, however, the general belief that many cases were, as a matter of fact, concealed. If

allowances be made for all probable sources of error, the greater part, if not the whole, of the excess of the total mortality from all causes over the normal mortality for the seven months in question ought apparently to be accepted as the actual mortality from plague; which must, in this view, be taken to have been, for those months, not much below 20,000.

Assuming it to have amounted to 20,000 in the 12 months from the 1st October, 1896, to the 30th September, 1897, that would represent a death-rate from plague of more than 2·4 per cent. of the population, if it had remained at its normal figure of 820,000. During the plague, however, there was a large exodus of the people. At one time, Bombay is supposed to have been emptied of nearly one-half of its inhabitants. But there were many immigrants also, and no accurate estimate of the actual population at any particular time seems possible.

In the whole Presidency, the total number of plague cases reported up to the 2nd July, 1897, amounted to 37,000, and the number of deaths to 30,000, or 81 per cent. of the seizures. For reasons similar to those just stated, it may be assumed that the actual numbers of seizures and deaths were much larger. I may add that, up to the end of last year, 56,000 deaths from plague had been reported for the whole Presidency. The real number was probably not less than 70,000.

MORTALITY IN SOME PREVIOUS EPIDEMICS.

It is interesting to compare the foregoing figures with the alleged or recorded mortality in some other epidemics.

In the plague of 1361-62, the second of the three great pestilences which devastated England in the 14th century, one half of the population was swept away.* No registers of deaths were, however, kept at that time.

I am indebted to Mr. Baldwin Latham for a most carefully prepared record of plague mortality, as registered in London since the year 1538, when Thomas Cromwell, Lord Privy Seal, first ordered public registers of weddings, christenings, and burials to be kept. The record is relevant to the subject of this paper in reference to one of the conditions which apparently favour the growth of epidemics, as I will explain presently. But I here note that the presence of plague in London is recorded in no less than 86 years in the period between 1543 and 1679. The returns do not represent

* Mr. Wright's Introduction to *Piers Plowman*.

the full mortality, as there are parts of London for which no registers are forthcoming; and, especially after 1640, there was a notable absence of returns for Dissenters. In 1562 there were more than 20,000 deaths in London from plague, which is said to have been brought by soldiers returning from the Continent. In 1581-82, nearly 7,000 deaths were recorded. In 1592, a year of excessive drought, 11,503 persons died from plague in London and the Liberties thereof between March and December. In the following year the plague raged in many country places. In 1625, the mortality exceeded 44,000. Again in 1636, a year of great drought, it exceeded 10,000. In 1665,—a hot and dry year, the year of the Great Plague,—there were 68,596 deaths in a population of 494,000; the number of deaths having thus been 13·8 per cent. of the population.

In the plague at Moscow, in 1570, the number of deaths is reported to have been 200,000. At Naples 300,000 persons died in five months in 1656: in Prussia and Lithuania 283,000 persons died in 1704; in Stockholm, 40,000 in 1710; in Marseilles, from 40,000 to 60,000 in 1720. In 1720-21 the total mortality in Provence amounted to 87,659 in a population of 250,000.* At Hongkong, in 1894, there were 2,550 deaths, or 1 per cent. in a population of 255,000, during the four months that the epidemic lasted. As in Bombay, there was a large exodus of the people, to the extent probably of 100,000 of the inhabitants.

VIRULENCE OF THE DISEASE AT DIFFERENT TIMES.

The official returns furnish apparently the only data from which any approximate inference can be drawn as to the virulence of the plague in Bombay at different times. In the latter half of September, 1896, about 73 deaths were reported, but I have no note of the number of seizures. From the official records for the twelve months from October 1, 1897, we have the results in a tabular form, as now shown on the screen.

From this Table, it appears that the two worst months were February and March. In April, the percentage of deaths to seizures was higher than in January, but the mortality was lower. The percentage and the mortality were perceptibly reduced in May, and much more so in June.

Month.	No. of Seizures.	No. of Deaths.	Percentage of deaths to seizures.
October, 1896	389	276	70·96
November „	333	268	80·48
December „	1,655	1,160	70·09
January, 1897	2,374	1,825	76·87
February „	3,173	3,072	96·81
March „	2,495	2,257	90·46
April „	1,418	1,267	89·35
May „	448	327	72·99
June „	182	98	53·84
July „	62	44	70·96
August „	124	70	56·45
September „	221	168	76·01
Total for 12 months.	12,874	10,832	84·13
			Percentage for 12 months

VIRULENCE OF SOME OTHER EPIDEMICS.

The old accounts of plague epidemics do not give the proportion of deaths to attacks. At Baghdad official registers were kept during the outbreak of 1876, and showed that 55 per cent. of the attacks were fatal. At Vetlanka on the Volga, in the epidemic of 1878, the percentage was 90 per cent. In some villages of the Volga, every case was fatal.* At Hongkong, in 1894, the percentage for patients of Eastern extraction was 82, and for Europeans 18.

CLIMATIC CONDITIONS FAVOURABLE TO THE GROWTH OF PLAGUE.

I have already said that certain of the plague years in London were marked by excessive drought, and Mr. Baldwin Latham has drawn my attention to the fact that, though the plague was present for many years in London, yet it only appeared in the form of an epidemic in certain years. In most years it did not spread at all. This circumstance points to the conclusion that its growth to the dimensions of an epidemic is probably favoured by certain climatic factors. Great dryness of the air is, in Mr. Baldwin Latham's opinion, one of these factors. He finds that the conditions, when measured by the dryness of the

* Payne.

* Payne.

air, were identical in the several London epidemics and in the Bombay epidemic of 1896-97. The plague was at its worst in both cities when the air was driest. In London, in 1592, the worst months were July, August, and the first half of September; in 1603, from the middle of July till early in November; in 1605-6, and in the following year, August, September, and October; in 1624, from July to the middle of October; and in 1664-65, from early in July till near the end of November. In Bombay the worst months were from December to April, when the wind blows generally from the north-east, passing over large dried-up tracts of land before it reaches Bombay. The air current does not generally shift to the south-west and become a vapour-laden monsoon wind till about the middle of April. Mr. Nanabhai Ardesir Moos, the Superintendent of the Government Observatory in Bombay, has favoured me with information regarding the average weekly rainfall for the 24 years from 1847 to 1870, and the actual weekly rainfall in 1896, which was certainly of an abnormal character. Though the total rainfall of 1896 amounted to 87·6 inches, or 15 inches in excess of the average, it was not distributed over the rainy months of the monsoon in the usual manner. The third week in June was very rainy, the rainfall having reached 18·23 inches, or 11·60 inches in excess of the average. There was excessive rain again from the second week in July to the 18th August, and then from the 19th August to the 29th September the rainfall only amounted to 3·38 inches, as against an average for that period of 13·06 inches. It was less than the average in each week of that period. This circumstance was most exceptional, even for a famine year, for in the two famine years—1876 and 1877—much more rain fell in September than in September, 1896; and October, 1896, was dry and hot. This state of the weather may have been favourable to the establishment of the epidemic, which increased in virulence as the air became drier. The circumstance that the Hongkong epidemic of 1894 was preceded by an unusual drought, lasting for seven months, also seems to support Mr. Baldwin Latham's view; and, though the occurrence of rain within a week after the outbreak failed to check it, yet it should be noted that the Chinese themselves believe that the plague is favoured by a long continuance of dry weather, and that a downpour of rain for two or three days will stop it. The cessation of the plague in Naples, in the 17th century,

seems also to have been ascribed to a similar cause. The author of "John Inglesant" says:—"The night after Inglesant had met the friar in Naples, there was 'the sound of abundance of rain,' and 'the plague was stayed.' As constantly happened in the cities desolated by this mysterious pestilence, no adequate reason could be assigned for its cessation. Some change in the state of the atmosphere took place, and the sick did not die—at least, in the same proportion as formerly. This was the only indication that the most acute observer could detect; but the change was marvellously rapid." Mr. Fraser, the Consul at Pakhoi, observes that, "as a rule, the summer rains, washing the streets, put a end to the plague for the year."*

Dr. Hirsch examines, only to reject, the theory maintained by Pugnet that, in Egypt, the plague "is always an affair of a humid atmosphere;" for many plagues, he says, "have broken out and run their course under circumstances of place and time which have altogether excluded the influence of a high degree of atmospheric moisture."†

It has been noted, however, that a temperature of 80° or 85° Fahr., or more, "combined with absence of moisture," usually stops an epidemic.‡ In Northern India, Dr. Francis observed that, so long as the air was moist, the plague remained unchecked at a time when the temperature in his tent ranged from 83° to 95°, and when, in a grass hut, it rose to 105°. He held, also, that a lower temperature, "with dryness," rendered the poison inert. It is difficult to bring these views into harmony with the generalisations suggested by recent observations in Hongkong and Bombay. It is remarkable that at Alexandria, from 1834 to 1843, the plague generally became epidemic between October and January, and sometimes later. In most years, there was a distinct increase of mortality in February. In 1835, March was a month of exceptional mortality, there having been 4,459 deaths, against 951 in February and 2,016 in April. It was observed that the epidemic generally ceased in each year at Alexandria on St. John's day—June 24—and at Cairo at the summer solstice—June 21.§

Plague seasons have been noticed also in Syria, at Aleppo, Smyrna, Trebizond, Algiers, and elsewhere. In Persia, the plague season varies in different parts of the country. In northern countries, epidemics have generally started in the spring, been most active in

* *Blue-book*, "Hongkong," C. 7451, 1894.

† Hirsch, p. 517. ‡ Payne. § Hirsch.

August and September, and ceased in winter; but in Moscow, in 1770, and on the Volga, in 1878-79, "the plague raged during severe winter weather." In Northern India and Arabia, no particular association with the seasons has been traced. In Irak, according to Dr. Payne, the plague dies out suddenly in the summer. When the temperature rises above 86°, it begins to diminish, and it ceases abruptly at a temperature of 113°.*

The temperature of the air would seem, therefore, to be also a relevant factor in connection with outbreaks of plague.

Dr. Hirsch sums up the evidence on this point with the proposition that "a moderately high temperature favours the epidemic prevalence of plague, but that extremes of heat and cold mostly cause the extinction of the epidemic, or are little favourable to its breaking out." The danger of generalising on this subject is illustrated, however, by his further remark that even to this rule there are many exceptions! At Bombay, the mean annual temperature of the year 1896 was 80·7° Fahr., the highest temperature on record—except in one year—for 51 years. As regards temperature, therefore, the year was also exceptional, and may have presented conditions especially favourable to the growth of the plague bacillus. I am indebted to General Gatacre for the valuable chart on the wall, which shows the course of plague mortality in 1896-97 (as inferred from the total mortality) in relation to the daily temperature, the humidity of the air, the velocity of the wind, the amount of clouds, and the fluctuations of the population. I will not discuss the details of this chart, but will only point out that the two thick black lines show the temperature, the red line the total mortality, and the green line the humidity of the air. It appears that at the time of the greatest mortality there was a distinct lowering of the lines of temperature and humidity.

LOCAL CONDITIONS.

It is difficult to say with confidence that any particular state of the soil, or kind of soil, or any particular elevation pre-eminently favours the growth of the plague. Dr. Weir has pointed out that there was an abnormally high level of the sewage in the arterial sewers of Bombay after the heavy rain in the earlier part of the monsoon of 1896. Five millions of gallons of water were daily left in the soil, that being the excess of the water coming into the city over the amount of sewage going out

—"a balance indicating great danger at all times."

Mr. Baldwin Latham observes, in his report on the sanitation of Bombay (1890), that underground water obeys exactly the same law as water flowing on the surface, and that the filling up of the low-lying parts of Bombay known as the flats, with refuse, without first providing for their effectual drainage, has necessarily raised the level of the subsoil water as well as the level of the floods over the island, and that, as the process of filling up the flats has been carried on, deaths from respiratory diseases have greatly increased also, the mortality from this cause (not including deaths from phthisis) having increased from 1,974 in 1880 to 4,132 in 1888. Dr. Hughes is of opinion that the excess of subsoil water due to the heavy rain favoured the development of the plague in those low-lying parts of Bombay in which it first appeared. When the plague reached higher ground on Malabar Hill it was noticed that it attacked the people in huts either on the level top of the hill, on level ledges, or in a depressed hollow from which there was no drainage. But it is impossible to deduce any general theory from such partial observations; for in the Himalaya districts the plague has occurred not only in "cup-like valleys," but also on precipitous mountain sides,—in gorges reached only by cradle swings, and in upland slopes close to the springs of rivers; and in an atmosphere and climate the "finest and purest in the world!"* It is, of course, possible that these advantages are neutralised by the social condition of the villagers in Garhwal. Rennie, as quoted by Hirsch, observes that "the filth everywhere—in their villages, their houses, and their persons, . . . and the advantage the natives in other parts of India of living in the open air is lost to the villagers . . . from the necessity of their crowding together for mutual warmth and shelter against the inclemency of the weather."

In Egypt, certain processes in the soil, where it has been saturated by the overflow of the Nile, and then left to dry by the waters running off, have been held to be directly concerned in the development of the disease; but in England, Germany, and Scandinavia, the plague has occurred at places where there have been no such conditions of the soil.† In Kurdistan it has prevailed in the severest winter weather on dry limestone, at an elevation of 6,500 feet. At Assir, in Arabia, the plague prevailed on

* Payne.

• Hutcheson.

† Hirsch.

high plateau, while the swampy plain below was exempt. On the banks of the Euphrates it has been found in marshy places; and in Bombay the municipal authorities were distinctly of opinion that dampness of houses and even of public streets, "had a malevolent influence on the propagation of the disease."*

In India, the plague has certainly prevailed equally in damp villages, on jungle-covered slopes of mountains, on the dry soil of Kathiawar, and on sandy and barren plains in Guzerat.† All, apparently, that can be affirmed is the negative proposition that no particular soil, or state of the soil, and no particular elevation has been shown to be unfavourable to the growth of the plague bacillus; and that it is not impossible that defective drainage and the undue raising of the level of subsoil water may favour the growth of the plague bacillus when once it is introduced, and may at the same time so lower the general level of public health as to predispose the people to attack.

PERSONAL CONDITIONS. SUSCEPTIBILITY OF DIFFERENT RACES.

As regards the immediate personal conditions which render a human being susceptible to an attack, there seems to be a fair consensus of opinion that healthy, well-nourished people are less liable to be infected, or, if infected, are better able to resist the plague than the weak or the sickly or the ill-fed. This consideration may perhaps account for the comparative immunity enjoyed by the members of certain communities in Bombay, and especially by Europeans and Mohammedans, and to a less degree by Parsis; as traced in the chart, which will now be shown on the screen. Europeans enjoyed comparative immunity so in Hongkong in the epidemic of 1894, but not to the same extent in the epidemic of 1896; and in Egypt it was observed that "the larger number of plague deaths occurred among the Negroes, next to them among the Berbers and the Nubians, and in the third degree among the Arabs; while the Europeans were the most favourably treated, those from the northern countries in the first place, and less so the southerners (Turks, Greeks, and Armenians)." Dr. Hirsch thinks it probable that the "social element" gives the key to such differences, not that they can with any confidence be attributed to degrees of racial or national predisposition. In the Himalayan slopes, the plague has not spread among Europeans. Their number,

however, is small. Nor can we forget that for a long series of years, the plague was practically endemic on European soil; but even then it was the poor who suffered. This was so in the Great Plague of London; and even 300 years earlier, it was noticed of the plague of 1362 by a contemporary writer, Symon de Covino, as narrated in Mr. Wright's introduction to "Piers Plowman," that "he who was ill-nourished with unsubstantial food fell before the slightest breath of the destroyer. To the poor, death was welcome, for life is to them more cruel than death. But death respected princes, nobles, knights, judges, gentlemen. Of these, few die, because their life is one of enjoyment." It is added, however, that another pestilence came which visited the classes who had before escaped, because they had not profited by the warning given them.

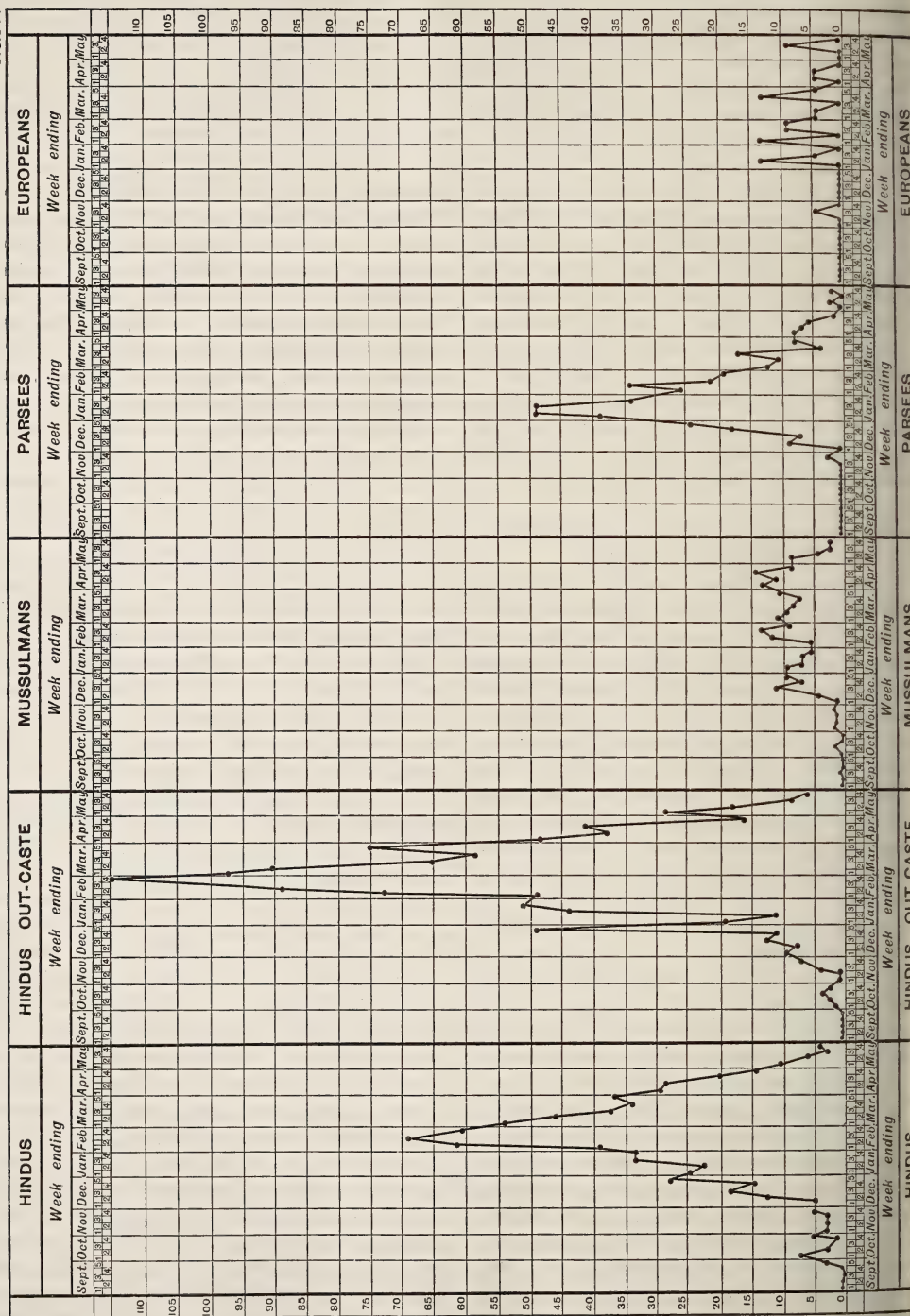
Dr. Grayfoot says that "the filthy, insanitary houses and chawls in which the poorer natives live," and their "utter disregard" for sanitary laws, are "all important factors to be remembered" in connection with the firm hold taken by the plague in the city of Bombay. Dr. Weir estimates that 70 per cent. of the population live in tenements of the class inspected by Dr. Cleghorn, to which I have already referred. "Overcrowding," says Dr. Arnott, "is a great evil in Bombay. . . . I have seen rooms occupied and overcrowded, which had no window or means of ventilation except the door, and so dark that at noon one required a light." Dr. Hughes remarks that the locality where the plague first appeared was crowded, but was not otherwise peculiarly favourable to the development of the disease. Some of the houses in this part of the city were inhabited by people in good circumstances, but are said at first to have been very dirty. Mr. Playford Reynolds tells me that, when he visited these houses in March, while on inspection duty with Dr. Pollen, he found them clean and well ventilated. The plague did not again appear in them during the epidemic of 1896-7.

All authorities are agreed that the accumulation of filth in streets and houses, the defective disposal of refuse of all kinds, the overcrowding and insufficient ventilation of dwellings, "the frightful misery" resulting from the disregard of considerations of rational hygiene, "in all that relates to dwellings, clothing, and the like," have always fostered the epidemic prevalence of plague. "The classes most exposed to such injurious influences have suffered from plague most severely."*

* Mr. Snow's "Report." † Hirsch.

* Hirsch.

No. IV.



PLAGUE MORTALITY IN DIFFERENT COMMUNITIES.

INITIATION OF PREVENTIVE AND REMEDIAL MEASURES AT BOMBAY BY THE GOVERNMENT.

It was to the necessity for the abatement, as far as possible, of all injurious influences and of destroying the exciting factors of disease,—that is, the living poison-germs themselves,—if possible and where possible,—(a task of the most difficulty when the germ has once crept unnoticed and began to multiply in a crowded population)—that attention was directed, after it had once become clear that an epidemic of plague was establishing itself in Bombay.

On September 28, 1896, Dr. Cook, the late Surgeon-General with the Government of Bombay, reported that he had seen about twenty cases of a mild type of bubonic plague in Bombay, and that preventive measures were in active operation. On September 29, the Government directed Dr. Clarkson, the Sanitary Commissioner, and Dr. Waters, to give all possible help and advice to the Municipal Commissioner, and appointed a Committee of inquiry, of which the Municipal Commissioner was the president, and the Executive Engineer of Bombay, the Sanitary Commissioner, and some of the leading physicians, European and native, were members. On September 30, the Surgeon-General reported that the disease had probably been in existence for more than a month, and that the utmost activity prevailed in the infected area on the part of the Municipal Health Department. On the 1st of October he forwarded the committee's report, and, on his requisition, two assistant-surgeons and four hospital assistants were supplied by Government to attend on the sick. Two more assistants were supplied later in the month. Suburban municipalities were also warned, and furnished with the means of detecting the plague. At the same time, the Government appointed a Scientific Committee to ascertain the nature and history of the disease. The late Dr. Manser, senior physician of the Amsetji Hospital, was the president of this committee. He was attacked by the plague early in January, while engaged in his professional duties. His death was deeply deplored by all classes of the community, by whom, as by the Government, it was regarded as a public calamity. Professor Childe, of the Grant Medical College, was also appointed a member of this committee, in association with Professor Haffkine and Mr. Hankin, and a young Parsi physician, Dr. Surveyor, who was the first medical man to identify the plague

microbe in Bombay. On the 6th October, the Municipal Commissioner issued, with the sanction of the Government, a notification under section 434 of the Bombay Municipal Act, and from that date he possessed the requisite legal power to enable him to enter and disinfect buildings, to remove goods therefrom, to remove to hospital persons suffering from plague, and to isolate houses in which cases of plague had occurred. The measures at first enforced under this notification increased the alarm already caused by the spread of the disease, and Mr. Snow found it necessary, before the end of October, to relax the stringency of his original regulations for segregation and removal. He explains very fully in his report that panic was thus allayed and other evils averted, which, at such a time, would have involved "the absolute ruin of the city and the cessation of all sanitary measures both then and thereafter." I will revert to this matter presently.

MEASURES TAKEN BY THE MUNICIPAL AUTHORITIES.

I will make no apology for giving precise details of the more important measures taken by the municipal authorities. Infected houses were, from the beginning, treated practically as if they were on fire, and were flushed from flushing pumps and fire-engines with water charged with disinfectants, chiefly cresol or phenyle preparation and permanganate of potash. Sulphur was burnt inside houses, particular parts of which were also lime-washed. Drainage pipes were specially disinfected, and when in bad order were removed or cleaned. Disinfectants were freely used, not only in infected houses, but in the adjoining houses, and were freely distributed to the people. All obstructions to the entrance of light and air were removed as far as possible. In every part of the city tiles were taken off the roofs of houses; thousands of persons were removed from infected buildings; and all domestic refuse and articles likely to be infected were burnt or exposed to the sun or disinfected.

Besides lime-washing affected houses, the municipal officers undertook the work of lime-washing throughout the city and its suburbs on a very large scale, in advance of the disease. A large staff was engaged for this work in December, 1896. But lime-washing was begun in September, and was continued until the following March. During these seven months the municipality issued lime-washing

notices to 3,507 owners of houses, and made similar demands in other forms on many others.

Whenever infected houses had been thoroughly cleansed and vacated for a short time, fresh cases of plague rarely occurred in them. There were some lamentable exceptions, however, to this rule, and among the photographic slides, which I will show you presently, I have one of a house in which no less than 53 deaths occurred.

Very early in October, before the disease appeared in the Fort district, which contains 36,796 inhabitants, concentrated in 1,664 houses, that district and also the Market section, which contains 44,751 inhabitants in 1,724 houses, were taken in hand, and alleys, court-yards, drains, and portions of houses were flushed and disinfected. General measures were also taken to destroy and burn dead rats.

A house-to-house visitation by medical officers was also instituted,* and poor patients were treated as far as practicable in their own houses and given relief in money. Dr. John Pollen, the acting Collector of Bombay, did good service by starting a fund for this purpose, and aid was thus given to many poor sufferers when their need was the sorest.

Street watering was also suspended, and from the outset the water supply was stopped and reduced wherever it produced excessive dampness. In the low-lying district of Kamatipura, which has a population of 29,203, the whole of the water-pipes were cut off inside buildings, and stand-pipes were put up outside. All unclaimed dead bodies were cremated at the expense of the municipality. All temporary huts and shelters in which plague had occurred were burned. Buildings unfit for human habitation were condemned under magisterial orders. Infected warehouses were closed for twenty days and infected shops for two days each, and were also disinfected, with their contents.

As observed by Mr. Snow in his report of October 2, 1897, "every kind of measure known to science was tried in Bombay at one time and another, and, as further experience was gained, the measures were modified from time to time." The Municipal Executive had to deal with a rising epidemic, and encountered the brunt of it till the crisis was passed, and Mr. Snow is able to record the fact, noticed by all leading scientists who came to Bombay, that never, in the course of history, had a

rising epidemic of plague in a vast city, such as Bombay, been kept within such moderate bounds.

DEPUTATION OF DR. CLEGHORN TO BOMBAY.

Early in January, 1897, the Government of India deputed Dr. Cleghorn to study the position of affairs in Bombay and to settle a plan of action in the event of the spread of the plague to other places. Acting on the view (to which I have already referred) that the incidence of plague was greatly due to local conditions, he recommended the removal from infected houses of all their inmates, the healthy as well as the sick, in order that the Health Department might the more effectually carry on the work of cleansing and disinfection. The adoption of his proposals to their full extent would have involved the construction of health camps for about 30,000 persons of different races, castes and creeds; and within the limits of the municipality there was no site which would have accommodated one-tenth of this number. It would have taken several months to construct the requisite huts or sheds on account of the scarcity of material and especially of labour, about 300,000 people having already left Bombay; and the buildings, when ready, could have been used only for a short time, as the light material of which they were to be made would have provided no shelter against the monsoon rains. Moreover, an attempt to remove many thousands of healthy people to temporary huts outside Bombay could not have been made without a show of force, such as indeed was necessary later in the year when the work of segregating the sick was carried out systematically. Such an attempt in January or February would have frightened the people, emptied Bombay of the whole staff of sweepers and scavengers employed on its ordinary, daily sanitary work—a disaster more terrible than the plague itself—and completely paralysed a trade by closing shops, mills, docks, and many other places of business. But though the adoption of Dr. Cleghorn's proposals in the entirety was found to be impracticable, the Bombay Government distinctly recognised the evacuation of infected houses and the segregation of the healthy as desirable measures which should be carried out to the utmost limit consistent with the avoidance of a general panic; and on the 23rd February the Government of India was informed that, on the occurrence of the plague, and even before its outbreak, gangs of labourers had been engaged

* *Blue Book*, "India: Outbreak of Plague," C 8386.

employed in taking off the roofs of houses, hundreds of which had in consequence been vacated and that huts had been erected for the inmates. The general object in view had thus been studiously prosecuted. In the course of the correspondence, the Government of India expressed its appreciation of the liberal measures sanctioned by the Municipality and of the energy displayed by the Municipal Commissioner, the Health Officer, the Executive Engineer of the Municipality (Mr. C. James), and their subordinates. The Bombay Government recorded its opinion that these officers had shown sound sense also.*

PLAGUE HOSPITALS.

Such plague cases as could be segregated were at first sent to the Municipal Hospital in Arthur-road, which was opened for the treatment of infectious diseases before there was any indication of the plague. Up to October, 1896, the only other hospital where plague cases could be received was St. George's Hospital, which was available only for Europeans. In October, two private hospitals were opened by the Hindu community for Hindu patients, but were closed on account of the high mortality in them and the alarm caused by the establishment of hospitals in crowded localities. In December, hospitals were opened for Parsis and Jains and for the workpeople on the Port Trust estate; and, in January, for Hindus and servants of Europeans. Much good work was done in this latter hospital, under the supervision of Professor Oswald Muller, of the Elphinstone College, and Mr. Barker, at a critical time when alarm was spreading. The attention and kindness shown to patients went far to arrest the flight of household servants, which had already begun. The old, historic Government House at Parel was placed by Lord Sandhurst at the disposal of the Health Department in February, and was afterwards maintained in complete working order by General Gatacre's committee. It had rarely ever been put to a nobler use. A jail hospital in Parel-road, a second municipal hospital in Grant-road, and fourteen private hospitals were established in March. In the course of this month, the sanitary administration of Bombay was entrusted by the Government to General Gatacre's committee, and to the measures adopted by that committee I will presently refer. In April and May, seventeen

more hospitals were opened, most of which were private hospitals. The map on the wall, for which I am indebted to General Gatacre, shows the positions of the principal hospitals, the names of the District Medical Officers, and the number of houses in each district, and also the population.

POPULAR DREAD OF HOSPITALS.

There can be no doubt that, at an early stage of the epidemic, the poorer classes had lost all confidence in the medical treatment of plague cases; and it is estimated that only a small percentage of persons attacked by the plague were seen or treated by medical men. Many infected persons were not brought to the hospitals till they were in a dying state; and when death, hastened possibly by the fatigues of a long journey, was seen in such cases to follow speedily on admission to hospitals, the wildest rumours regarding the alleged ill-treatment of patients by medical officers were spread abroad and believed. Many thousands of those who fled from Bombay were impelled by fear of the hospitals as much as by fear of the plague itself. But flight from unknown evils was not the only expression of popular ignorance, fear, and distrust. On October 29, 1896, an attack was made by a gang of about 1,000 Hindu mill-hands on the Arthur-road hospital, which it became necessary thereafter to protect by a police guard; and even before that date the members of the sanitary staff of scavengers were "seeking every excuse to leave the city, and had only been kept in hand by the ceaseless exertions of the Police Commissioner, Mr. Vincent, with his detective staff, the Health Officer (Dr. Weir), and his capable assistant, Mr. Leask."* There can be no doubt also that the people dreaded the separation of the members of families from each other which strict segregation of the sick involved. A Mussulman hospital near the Victoria Gardens was closed for this reason, and a new one opened by General Gatacre in the quarter where the patients lived, so that their friends might be near. And indeed, when hospitals became numerous, the relaxation of the strict rule of segregation by the admission of friends tended greatly to allay popular suspicion. Even so early as in January, 1897, Dr. Cleghorn saw indications of a change in popular feeling and noted that the people were beginning to recognise the advantages of sanitation.

Blue-book, "India: Outbreak of Plague," No. 2. 8511.

* Mr. Snow's "Report."

MEASURES UNDER THE EPIDEMIC DISEASES ACT. GENERAL GATACRE'S COMMITTEE.

There can be no question as to the magnitude and difficulty of the work devolving on the Health Department, and though, during the latter half of February, the mortality was decreasing, still the necessity for further measures became apparent, not only on account of the continuance of the disease, in spite of the efforts of the preceding four months, but in view also of the communication of the plague by refugees from Bombay to other parts of the Presidency. On the 4th February, the Epidemic Diseases Act, which conferred very large powers on the Government, became law throughout British India, and on the 17th February the Government empowered the Municipal Commissioner, under that Act, to prevent the use temporarily or permanently of buildings unfit for human habitation. On the 18th, the Collector of Bombay, Dr. Pollen, was appointed to value all buildings demolished by the Municipal Commissioner under the powers given him, and the Superintending Engineer, Mr. Reynolds, was appointed to assist him. On the 20th February, special officers were appointed as Plague Authorities throughout the Presidency, exclusive of Bombay and the military cantonments, to enforce rules for the examination and detention of railway passengers at certain stations and also travellers by road, for isolating infected persons, emptying and cleaning insanitary houses, destroying insanitary huts and infected clothes and regulating burials. On the 2nd March, Drs. Lowson and Reade, who had served in Hong-kong, were appointed Plague Commissioners to advise and help all officers and committees engaged in plague operations. On the 5th March a committee, consisting of General W. F. Gatacre as chairman, and Mr. Snow, Dr. Dimmock, and Mr. James as members, was appointed to carry out measures of suppression and prevention in Bombay under the immediate orders of the Government. The committee was invested with the requisite legal powers, and the payment of all expenses was to be met from the municipal fund. Lord Sandhurst informed the Corporation that it had become an Imperial necessity, in consequence of the spread of the plague beyond Bombay, for the Government to take the control of plague operations absolutely in its own hands in order that individual efforts, whether of municipalities, local boards, or local officers, might be systematic and co-operative, and the methods

employed consistent, complete, and, if possible, successful before the commencement of the monsoon rains in June. The three principal objects to which the attention of the committee was directed were, (1) an organisation for the discovery of all plague cases, (2) the treatment of all cases in hospital, and (3) the gradual segregation, as far as possible, of persons who were probably infected by living in the same room with plague patients, or by attending on them; and Lord Sandhurst explained to the chairman of the committee the importance, in giving effect to these measures, of ensuring respect for the privacy of women and for religious usages, of opening the hospitals, as far as possible, to the friends of patients, for whom accommodation was also to be provided near the hospitals, in order that they might see for themselves that the patients were well cared for, and of preventing distrust by persuasion and firmness. Advantage was also to be taken of the assistance of native gentlemen, many of whom had already offered their services. In the spirit of these well-considered and considerate instructions, and with tact, resourcefulness, and energy that never failed, General Gatacre, in association with his committee, conducted the requisite plague operations as long as the epidemic lasted. The city was divided into ten districts, as shown on the map, and commissioned medical officers, drawn from all parts of India, were placed in charge of them, with control over inspectors and the sanitary staff which had been organised and trained by the Health Department, and the subdivisional medical officers recruited from the local practitioners and medical students.

EMPLOYMENT OF SOLDIERS ON PLAGUE DUTY.

Soldiers, both European and Indian, eagerly responded to General Gatacre's call for volunteers, officers and men alike having sent in the names *en masse*. In all, 557 men, of whom 20 were British soldiers, were employed on plague duty under seven British officers, 11 Native officers, and 35 non-commissioned officers, British and Native. They lived in special segregation camps, and were taught nursing and the duties incidental to the search of houses for plague cases. The hospital at Government House Parel, was worked by military labour, and was used as the training school. Services of great value were rendered by this military contingent at a time when it was "almost impossible to procure servants of any description in plague

hospitals.*" The troops were also employed in small detachments of three or four men in house-to-house visitation with the Justices of the peace and plague officers, and in disinfecting work.

Whether employed in house-to-house visitation, or as hospital clerks, store-keepers, ward-masters, dressers, cooks, or orderlies, or in drawing spring ambulances with light bicycle wheels, which the committee brought into general use, much to the comfort of patients, the troops had their time fully occupied. Indeed, sometimes the work was exceptionally heavy. It is gratifying to note the extreme cordiality that sprang up between the soldiers and the civil population. "Every kindness, consideration, and civility were shown," says General Gatacre, "to the people by the men. This was thoroughly appreciated, and the result was the entire absence of complaint." The presence of the troops with search parties prevented any opposition to sanitary measures which the ignorant or the turbulent classes might have been disposed to offer, while the presence of resident Justices gave assurance to the people that their religion was not in danger. Towards the end of April, General Gatacre told me that no plague cases then escaped notice, but were immediately removed, and the families of patients segregated, the houses being at the same time disinfected.

Before the middle of May, 1897, there were 11 plague hospitals in working order throughout the city, of which 31 were opened after the appointment of the committee. Of these 41 hospitals, 27 were private institutions for the use of members of particular castes, communities, or sects, and were under the supervision of medical officers working under the Plague Committee. All castes, creeds, and races joined in the movement, and great credit is due to the munificent founders of these private hospitals, and to the medical men who most cordially came to the assistance of the committee in working them.

HOSPITAL NURSES.

Hospitals without nurses would be poor places; and the committee lost no time in securing a staff of competent nurses from England and elsewhere. Before their arrival, timely assistance, the value of which it is impossible to over-estimate, was given, first of all, to the municipal authorities, and afterwards to General Gatacre's committee, by the All

Saints' Sisters at Mazagon and the Daughters of the Cross at Bandora; and, later on, by Sisters from the Clare-road Convent and ladies connected with the Church Missionary Society; and also, I believe, by several Hindu and Parsi ladies. The All Saints' Sisters began work in the Parsi Hospital on the 6th January, and in the Arthur-road Hospital on the 6th February. Other hospitals were also served by them. The work was very heavy. The very first night that one of the sisters was on duty at Arthur-road, no less than eleven patients died in the hospital.* The Bandora sisters worked at the Government House Hospital at Parel from the 21st February, and elsewhere at Bandora and Mahim. General Gatacre's full and comprehensive report contains some pathetic stories illustrating the gratitude of plague-stricken patients for the kindness and care shown them by these brave women, whose self-denying services will indeed be long remembered in Bombay. One of their number, Sister Elizabeth of Bandora, fell ill of the plague and died at her post.

The skilled attention bestowed on plague cases by the sisters and, after they were relieved of their duties, by the efficient staff of nurses sent by the Secretary of State from England, or engaged locally, was of signal assistance to the Plague Committee, and the large staff of civil, military and medical officers associated with them, in their efforts to overcome the popular dread of hospitals and opposition to sanitary measures generally; and, long before the cessation of the first epidemic, the officials and others employed on plague duty were welcomed by the people in their visits to infected houses and hospitals. I shall not soon forget a little incident which occurred in my presence a few days before I left Bombay. I had accompanied General Gatacre, Dr. Weir, Dr. Dimmock and other officers in their daily tour of inspection, and as we were entering the convalescent ward of the Mohammedan hospital, established by Mr. Adamji Pirbhoy, the patients showed every sign of pleasure. Many rose from their beds, weak as they still were, and salaamed to us. They could not have expressed their gratitude more unmistakeably.

INSPECTION OF PASSENGERS, &c.

The Plague Committee undertook other work which time would fail me to describe in detail, such as the organisation of an effective scheme

* General Gatacre's "Report."

* General Gatacre's "Report."

for the examination at certain railway stations of trains and passengers entering Bombay by the Great Indian Peninsula, and Bombay, Baroda, and Central India Railways, and for the inspection of the inward sea traffic, and of passengers landing at the several docks and piers—a duty which was most thoroughly carried out under the able supervision of Dr. MacCartie and Dr. Crimmin. The committee also assisted in every possible way the members of the German, Austrian and Russian Medical Missions, and the French and Italian officers in their researches. Plague operations were also carried out under their orders in the Kolaba district of the Bombay Presidency, and in the territories of his Highness the Rao of Kutch. These and many other matters are dealt with in General Gatacre's report.

I should have wished also to give you some information as to the disastrous effect produced by the plague on the trade of Bombay, and to explain the proposals of the Bombay Government for the restoration and sanitary renovation of the city. But the subject is too wide and I have already trespassed too long on your patience.

Nor can I speak of the important work done by the plague authorities in Karachi, Poona, Satara, Ahmedabad, Thana, Bandora, and many other places in the Bombay Presidency. It would be impossible to do justice to so complex a subject within the limits of this paper.

It is grievous to think that, in spite of the heroic efforts which have been made, with all the aids and appliances of modern science, the disease has appeared with renewed strength, and that an epidemic has been established for a second season in Bombay, thus repeating the history of former visitations in countries where sanitary methods were unknown. No doubt it is open to us to believe that the mortality in 1896-97 would have been higher if the plague had not been vigorously fought against, and to cherish the hope that, in the new Bombay, with an effective drainage system, well ventilated streets, and properly regulated dwellings for the poor, the plague germ will never again find a congenial home. But the situation is none the less depressing. Nor, apparently, can all reason for anxiety be removed unless Science, from the experience of the past four years, can suggest some effective means of eradicating the plague bacillus from all known plague centres and protecting all other places from its attacks.

I would only, in conclusion, remind you that,

dreadful and widespread though this visitation has been, and lamentable the loss of life, and though the prospect still is gloomy, yet the very intensity of the troubles which have beset the British Administration has called forth the noblest qualities of our officers and of private citizens, European and Indian. The head of the Administration, Lord Sandhurst, has exhibited a calm courage and determination, in the midst of appalling perplexities and dangers, worthy of his high position. The efforts directed by him to subdue the plague were described, as you may remember, by that gallant soldier, Sir Henry Havelock-Allan, in one of his last letters, as "superhuman;" and the members of the public service of all grades and classes have borne and are still bearing the unprecedented strain that has been put on them with unwavering steadiness, while public-spirited men and women, not a few, with no stimulus of official responsibility to urge them on, have come to the help of the official authorities in a spirit of self-sacrifice and devotion beyond all praise.

DISCUSSION.

Sir RICHARD THORNE THORNE, K.C.B., F.R.S., said in one sense it was not at all appropriate that he should open this discussion, for he had never been in India, and knew little or nothing of Bombay. All he knew he had learnt from others; but there was one all-important point which occurred to him in listening to the paper, and that was that notwithstanding the almost superhuman efforts which were made during the 1896-97 outbreak, efforts of which the nation might well be proud, plague had recurred in Bombay as severely as the year before. They might, therefore, ask themselves whether there was not some reason for this, and he rather regretted that Mr. Birdwood had found it necessary to pass over, from want of time, the description of the native portion of Bombay contained in his paper. He had, however, stated that at least one form of plague might in all probability be due to the soil, and if one who had not had personal experience of plague might express an opinion, he might say that he had a distinct conviction that the recrudescence of the malady in Bombay was probably largely due to conditions of soil. When they remembered that one thimbleful of ordinary garden mould would contain millions of micro-organisms, happily not pathogenic ones, and when, as the result of experiments made under his directions for the Local Government Board, it was proved that if you took a soil absolutely free from any harmful organism, and inoculated it with one needle point of typhoid organism, that microbe had

already grown for over a year, and was still growing, they would have some idea of the power of soil as a medium for the propagation of preventable disease. He was at the Venice Sanitary Conference with two other British colleagues, representing this country, and Dr. Cleghorn was the representative of British India, and he did not hesitate to say that of all the communications made to that Conference none so deeply impressed the assembly as Dr. Cleghorn's description of the native portions of Bombay. They had heard of the chawls from Mr. Birdwood, and he would quote something which Dr. Cleghorn said about them. They were mostly great buildings, five to seven storeys high on the flat principle, each flat containing a long corridor with rooms about 8 by 12 feet in size opening into it on either side; these rooms were let out to families, and were ordinarily occupied by six to eight persons, or even more. The conditions of filth at the end of the corridors made it better not enter into. The buildings were surrounded by others of the same sort, and it was impossible, by reason of their proximity and the consequent overlooking, to let the window openings remain uncovered, and even if they were open the construction of the buildings deprived the buildings of light and air, so that artificial light was constantly required. Then there were narrow passages at the back, between two rows of chawls, which were supposed to be left for the scavenger, but instead of that they became the receptacle of filth blown into them from all the rooms, and they were hardly ever cleansed. Each chawl was stated to contain from 500 to 1,000 persons, and 70 per cent. of the native population were thus housed. Such places could only be seen in Bombay, and, as Dr. Cleghorn put it, the marvel was, not that they had so much plague, but that it had not carried away at least half of the population. They could easily understand that no efforts on the part of any Government or municipality could in an emergency deal with a gigantic evil like this. He deeply sympathised with those who found themselves the heirs of such a monstrous legacy. It was remarked at Venice by the representatives of all the nations of the world, from America in the West to Persia in the East, that such conditions were the ones which favoured plague. These were not the native habitations in one sense. They were the results of Western civilisation, and, as Dr. Cleghorn said, they had arisen in connection with the cotton industry. There was a density of population in these chawls three times as bad as any known in London. His main reason in thus referring to these conditions was that Mr. Birdwood said in one part of the paper that unless science could suggest some effective means of eradicating the plague bacillus from all known plague centres, they seemed to be in the face of a hopeless task. He entirely agreed that all sanitary measures ought to have a scientific basis, but at the same

time this was not a case for science at the present moment. There was a time when science having done all it could, practice had to step in. He feared, however, that this task would occupy practice for many years to come. Although the disappearance of the plague of London was wrongly attributed to the Great Fire, it would, from a purely medical point of view, be a good thing if the whole of that part of Bombay were burned down. He must say he heard Dr. Cleghorn's description of modern native Bombay with a sense of shame, for it was under the shadow of Western civilisation, in the most sinister sense, that this sort of thing had grown up. Taking these chawls and their surroundings as a "soil," in its widest sense, they constituted places where the plague bacillus would live, multiply, and propagate itself, and retain its power of doing mischief. It was probably not the present generation which was responsible for that sort of thing; but, if it be true that it had arisen in connection with cotton industries, it was the greed of gain which had largely led to it. It was not now so much the time for science as for practice. No amount of progress in science, no number of experts employed by any Government, could set aside the results of such gross breaches of the laws of nature. Nature herself was absolutely stern in allotting punishment as the penalty for breach of her laws, and she would accept no plea in justification. It was not the removal of the plague bacillus which was wanted, but the removal of the conditions which enabled the bacillus to flourish. The plague was brought into the port of London in 1896 in three vessels, but the newspapers would hardly give a couple of lines to the intelligence, for the people of England believed that we had removed the conditions which enabled these foreign infections to grow if they were imported. He feared they were too credulous, but it was on those lines that we had abolished quarantine, and it was on this basis that all English sanitary administration had gone.

Mr. H. A. ACWORTH, C.I.E. (late Municipal Commissioner of Bombay), said that scarcely anything had struck him so much as the fact that it had been thought necessary to defer the enforcement of segregation for so long out of apprehension of a strike on the part of the scavengers and sweepers. He knew very well what a cessation of their work would mean for the city. He had had a short experience of it during the riots. But he was not convinced that the risk of a strike ought not to have been incurred. At all events, it must be admitted to be a very serious fact that at such a tremendous crisis—a crisis of life and death, a crisis menacing the whole continent of India, which menace was now being fulfilled—the Bombay scavengers should have been allowed to dominate the situation. He had no doubt his successor, Mr. Snow, saw it in the same light, and would be glad to free the city from such thralldom. This could be done to some extent as far as the sweepers were concerned by connecting every house

with a sewer on the water-carriage system. This ought to be done as opportunities offered; and, as far as the scavengers were concerned, though they could never be wholly dispensed with, their numbers might be reduced by reducing the distances from the points of collection of street-sweepings to the points of disposal. To this end he would provide liberally for incinerators in all parts of the city. He had made proposals to this effect before he left India, and had experimented very successfully with an incinerator, designed by Mr. Garlick, which should be taken as a pattern. With regard to what had been said about chawls, he admitted that if the Bombay chawl was as bad as the Calcutta bustee it was bad, and no mistake; but it was not. There seemed to be misunderstandings on this subject. A chawl was simply a lodging-house, and as for all chawls containing 500 to 1,000 inmates, he knew plenty of chawls with less than 20. In one sense, the large, many-storied chawl was a "product of Western civilisation," as Sir R. Thorne Thorne had said. That is to say, Western civilisation had so raised the value of land that builders had to extend their houses vertically instead of laterally. Whatever the structural defects of the large chawls, the Municipality was not responsible for them. The building sections of the Municipal Act were excellent in the requirements they prescribed, but, unfortunately, they were rendered almost nugatory by one short sentence which confined them to buildings erected on sites previously unbuilt upon. By this provision the entire inhabited area of the city was excluded from the purview of the Act. Now this provision was not in the Bill as originally drafted by his predecessor, Sir Charles Ollivant. It was inserted subsequently: and by whom? By Government; and Government was responsible for the defects in the law in this particular. Turning to Mr. Snow's able report on the plague, he (Mr. Acworth) was struck by that officer laying so much stress on what had always been his own belief, viz., that the high level of the subsoil water in Bombay was to some extent answerable for the spread of the plague. He had no doubt the city was water-logged; and when one said water-logged in speaking of a great city, one said sewage-logged. Nothing was more important than to reduce this dropsical state, and this should be done by vigorous measures for intercepting storm waters on the high levels and carrying them direct to the sea, by enlarging the various sluices, and by stopping the waste of water. He regretted to read that Mr. Snow even yet seemed doubtful whether the Corporation would consent to metering the water supply. It was the only remedy for waste: make every man responsible in his pocket for the water running through his taps, and he will take good care that water does not run to waste. He had pressed this upon the Corporation with all his power, but had always been met by silly, sentimental platitudes about depriving the poor man of his water. The poor man, apparently, was to be allowed not only unlimited powers of irresponsible

waste of the ratepayers' money, but also of striking the city with pestilence. The Commissioner, however, now had the ball at his foot; he ought to be able to do anything. The Corporation must be thoroughly frightened, and, at all events, ought to be. No Commissioner ever had such a chance before. But he well knew the sort of difficulties Mr. Snow had to deal with. He well remembered a case in which a Parsi doctor—a man with a diploma from an English school of medicine (the Grant Medical College)—argued violently against all sewerage as such. He preferred that the city should live amidst its filth. On it being pointed out to him that in one single sewerage section the completion of the sewerage had enabled the Commissioner to close 1,800 cesspools, he said he preferred the cesspools! What could they do with men of that stamp, or the constituencies which elected them? The fact was that the natives of India, while they were keenly appreciative of the benefit of pure and abundant water, were absolutely blind to the advantages of drainage and sewerage. He scarcely knew one who really comprehended the subject. At every step they would obstruct and oppose. They would reluctantly approve main sewers and then jib over pipe sewers, and when the pipe sewers had been dragged out of them they would oppose house connections. But if ever there was a chance there was a chance now. The same difficulties beset sanitary progress all over India. It was utterly untrue to say that Bombay was a grossly insanitary town. Judged by any standard hitherto found attainable in the East, it was a very sanitary one, the best, he was sure, in India. It was as absurd to condemn it in the indiscriminating way he had heard done as it would be to say that there was not an enormous deal still to be effected. Before he sat down might he, without egotism, refer to a curious and interesting statement in Mr. Snow's report? This was that there had not been a single case of plague in his (Mr. Acworth's) Leper Asylum at Matunga, and this although the plague had raged all round it and up to within a few yards of it. He was sure his friend Mr. Birdwood would admit that he (Mr. Acworth) was entitled to claim this asylum as his own, and he would go farther and yet keep within the truth and say that by the policy of which this asylum was the exemplification, he had solved the leprosy question for the whole of India. The Leper Bill which had just passed the Government of India was the offspring of Matunga. Whether leprosy conferred immunity from plague of course he did not know. Mr. Snow, and he suspected justly, ridiculed the idea. But there were plenty of people at the asylum who were not lepers, the medical officer and his family, the sweepers, and so on; and he hoped he might claim that the immunity was really referable to the excellent way in which the site had been prepared, the wards, &c., built, and the whole asylum drained and kept clean and pure. If so, it was a striking example of what might be done to exclude the ravages of the plague bacillus.

Dr. W. J. SIMPSON, M.D. (late Health Officer in Calcutta), said that Mr. Birdwood, in his very able paper, had given a very vivid picture of what plague was, and what it could be, and, at the same time, he had made them acquainted with the measures employed in Bombay to stamp out the disease. He (Dr. Simpson) should not deal with the medical aspects of plague further than to say that he had held the opinion from the commencement that this was an expanding epidemic, favoured by local conditions, but acting independently of these. He based his opinion on the study of the gradual recession of plague from West to East, until it had reached its home in China, and, after a period of rest, its gradual recrudescence in China, and its advance westward once more. He should confine his remarks to the administrative machinery in Bombay for the suppression of the disease, and he hoped it would be understood that if they were somewhat of a critical nature, they did not apply to individual action or imply blame to any individual. All those engaged in plague duty deserved the highest possible praise for their heroic deeds; they rather applied to the system, or want of system, for which in the present condition of India there might be much excuse, but which could not, in his opinion, have any great effect in the desired object, namely, the stamping out of plague or any other large epidemic. Before leaving India last October he stayed one month in Bombay and Poona, studying the different forms of plague and the administrative machinery which was in operation for the suppression of the disease. The two points which attracted his attention most were, first, the great self-sacrificing devotion to duty displayed by all those engaged in attempting to check the progress of the disease, and secondly the inadequate means at their disposal for that purpose. If individual effort of a herculean nature could possibly have arrested the ravages of plague, it was certain that the plague in Western India would have been stamped out. But individual effort could no more stop an invading epidemic of plague, than a few heroes, unsupported by an army and experienced generals, could stop the advance of an invading army. The conditions of India were such that there was no trained service to deal with epidemic disease, and the time had yet to arrive when India should possess a well-trained army of sanitarians supervised by experienced Europeans to combat preventable diseases, just as it now possessed a native army of soldiers, led by British and native officers. To turn to Bombay, the Plague Committee there consisted of four members, and much more was expected of them than they could possibly perform. One would have thought that the stamping out of plague was of such vast importance at least to Bombay, which had lost $12\frac{1}{2}$ lakhs of rupees at the height of the epidemic, that the members of the Plague Committee would not have been called upon to perform duties outside those relating to plague. This was unfortunately not the case, and the only one who devoted his whole time to the work was Mr. James, the engineer. Surgeon-Major Dimmock, the only

representative of the medical profession on the Plague Committee, had to perform his ordinary duties at the Obstetric Hospital, of which he was the medical officer. It seemed to him (the speaker) a most curious arrangement that in an essentially medical question of this sort there should be only one medical man on the Plague Committee, and that that medical man should not be relieved of his ordinary duties. Further than this, disheartening difficulties presented themselves as regards the medical staff under the Plague Committee. First of all, it was not nearly large enough. He had a larger staff of trained medical men in Calcutta, merely keeping watch over the city with the object of stamping out at once any imported case of plague, than the Bombay Plague Committee had at its disposal in October last. Secondly, no sooner had a medical man become thoroughly acquainted with the district assigned to him than he was ordered off to the front or to some other locality. The committee were glad to get any medical men to join the search parties and assist them. He joined these parties and got an insight into the conditions under which the people lived in Bombay, and bad as the houses were in some parts of Calcutta, he found them infinitely worse in Bombay. In some localities such were the condition of the houses that nothing short of pulling down every other house would give fresh air and light to those standing. He trusted his remarks would be accepted in the spirit they were given, which was not one of fault-finding, but intended to point out that the system now in operation was almost useless for the purpose of getting rid of plague in India, and he hoped that the medical officers recently sent out by the India Office would be allowed to form the nucleus of a properly-organised sanitary service.

Mr. BALDWIN LATHAM said he began many years ago to investigate the very important question with regard to the sanitary matters on which very little had then been done. It had always struck him as a remarkable fact that malarious countries could be traversed with immunity in the daytime, but a single hour after nightfall proved fatal, and he thought there must be some special reason for that. He thoroughly believed in what Mr. Birdwood said about the influence of the sun destroying germinal matter, but there was a very much more potent reason than that why these malarial districts were at night and not in the day so dangerous. He made a series of experiments on earth hygrometry to find out exactly the conditions under which the earth parted with its vapours or exhalations, the conditions under which they were condensed or ceased to pass off, and he found, after some years of observation, that whenever the air was warmer than the soil condensation took place, and there was no exhalation whatever. That occurred in all these malarious countries in the day time, but at nightfall, when the temperature of the air fell to less than that of the soil, evaporation took place from the surface, and with it were

eliminated little organisms which produced disease. Applying this knowledge to Bombay, and looking at the periodicity of the outbreaks, it would be found in a most marked degree that the plague followed actually those same conditions that occurred in malarious countries. The amount of evaporation depended on the temperature of the dew-point. The power of the earth to part with vapour depended on its temperature also, and the higher the temperature of the earth in proportion to the dew-point, the greater the amount of exhalation taking place. He found with respect to Bombay, that although intense dryness of the atmosphere was one of the conditions under which the plague had developed, there was a difference of tension in the vapour of the water of the atmosphere, and that of the water in the earth. The greater these differences, the greater the chances of malarious influences being given off. This equally applied to a person suffering from the plague. If you put a patient in an atmosphere in which there was a very large amount of vapour, you would restrict the vapour passing from that body, and so prevent in a great measure the propagation of the disease germs passing away with the evaporation. It was very easy—though it was an uncomfortable feeling—to stop perspiration by saturating the air with moisture. In Bombay the greatest dryness of the earth takes place immediately preceding the time of the greatest intensity of the plague. That was to say, taking the temperature of the ground at 60 inches deep, and calculating the vapour tension compared with the dew-point, it would be found that December was the month in which there was the greatest amount of evaporation; then followed January and February, and then it began to decline until about April or May, and got to its lowest and kept pretty constant down to September. He had not got the records for last year, but there were no great differences in these temperatures from year to year, and in all probability when it came to be worked out that would account for all these little inequalities which occurred in the curve of deaths from plague in Bombay. It was a curious thing with regard to the plague in this country that when it was most epidemic it was almost always preceded by dry times just as it was in Bombay in 1896. The plague in Hong-Kong in 1894 was also preceded by a dry time, two rice crops having previously failed in consequence of the continuous drought. This was not the cause of the plague, because it was no doubt due to the disease having been brought from where it was endemic, and planted on a suitable soil. The remedy in great measure was to carry out works of a sanitary character. He knew Bombay very well, having carefully examined every portion of it, and he must say it was a misfortune that the early sanitary works there were not designed in a better way. European rules had been applied to Indian towns, which, in his judgment, having regard to certain circumstances connected with the population, were not sufficient for the purpose. If Bombay were to be restored to health, it was absolutely necessary that they

should have a better sanitary organisation. There should not be so many million gallons of water brought into the city daily by the admirable water-works, and only a very small proportion taken out again. It was left there after it was polluted by accumulation and poisoned, both the ground and the air. When these conditions were removed, no doubt Bombay would possess better health than it had ever enjoyed in the past. He intended to tabulate the returns for this year, and to make the observation public, as the matter was of so much importance, so that people should see the laws which seemed to govern the dissemination of the plague and similar diseases. In conclusion, he said they must all feel proud of their countrymen who had come forward to assist the city of Bombay in its dire distress.

Mr. BIRDWOOD, in reply, said that, at that late stage of the discussion, he would not refer to any controversial matter, but wished to endorse Mr. Acworth's remarks regarding the Homeless Leper Asylum at Matunga by citing the opinion of Mr. Snow that the singular preservation of the 300 inmates of that asylum was one of the most remarkable features in the history of the plague in Bombay, and was due to the fact that they lived in wide, airy, detached buildings, with free ventilation and sunlight throughout. Mr. Acworth was entitled to the great credit not merely of establishing the Leper Hospital, but of making adequate arrangements, at the outset, for the welfare, so far as that could be secured by human effort, of the unfortunate patients. As regards Dr. Simpson's remarks as to the failure of the means adopted for the repression of the plague to prevent its recrudescence, he would invite attention to a recent lecture delivered by Monsieur Haffkine at Poona, in which reference was made to the difficulties which had been encountered by science in dealing with certain other pests, such as the rabbit pest in Australia, the phylloxera in France, and the rinderpest in South Africa. If the first pair of rabbits imported into Australia had been promptly killed there would have been no plague of rabbits; and a similar remark was applicable to the phylloxera, an animal as large as the dot to the letter "i" on a printed page. The much smaller plague bacillus was much harder to deal with, after it had once established itself on suitable soil in a great and crowded city, and, as was now clear, it had established itself in Bombay for about five or six months before its presence was suspected. No excuses were needed for any possible shortcomings of those responsible for plague operations. He (Mr. Birdwood) at all events would make no excuses, where all had done their level best in pursuance of the best scientific advice available at the time. No doubt, as observed by Sir Richard Thorne, the time was come for "Practice to step in" where Science had shown the way. Science had indeed spoken, but he (Mr. Birdwood) hoped that she had not said her last word.

He did not wish to see the new Bombay rise on the ashes of the present city, for chemistry ought to be able to suggest an effective substitute for the remedy of fire, which had been recommended by some scientific experts. Such a remedy, if applied on a large scale, in so great a city would be attended with great danger, and would cause great loss and distress to the people. Still, he saw clearly, as did everyone in Bombay, the necessity for important sanitary reforms, which had been too long neglected. The civil authorities had not lost sight of their duty in this respect; and the progressive Government of Lord Sandhurst, as at present constituted, might be relied on to devise and carry through the large scheme for the sanitary renovation of Bombay which had for some months been engaging its most earnest consideration.

Sir OWEN TUDOR BURNE, G.C.I.E., K.C.S.I., on behalf of the Society of Arts as well as of the Imperial Institute, begged to tender very cordial thanks to Mr. Birdwood for his interesting address, and to Lord Spencer for kindly coming to preside. The Society was very glad to ask Mr. Birdwood to read his paper, not only because the plague in India was one of the most important subjects with which the Governments of India and Bombay had to contend, but because they knew him to be a man who not only had filled some of the highest positions in India, but had recently come home from Bombay, after going through some of the experiences he had so graphically described. They also thanked the noble Chairman for his presence, not only because he was a statesman for whom they felt great respect, but because by his presence he showed an interest in the great empire of which they were all so proud.

The CHAIRMAN said he desired to add his share of thanks to Mr. Birdwood for the admirable paper which he had read. They knew that in England, where we had considerable experience in sanitary matters, and where people were more or less instructed, too often when trying to carry out sanitary works there was an immense amount of prejudice and ignorance to cope with which prevented what was necessary being done. How much more then in India, where there were so many prejudices and superstitions, and where the people were less instructed in these matters, must the difficulties be. They were all very glad to have heard from one so lately on the Council in Bombay, so interesting and instructive a paper, and he might say, for himself, it had given him great pleasure to be present.

The following letter appears in *The Times* :—

At the lecture on the above subject given in the Imperial Institute to-day some grave reflections were made—not by the lecturer—on the Indian Government with respect to the housing of the poor in the city of Bombay, and therefore the Government

might possibly be held responsible for the outbreak of the plague. Such an inference is unreasonable in the extreme. We were told of the large amount of sympathy a certain Surgeon-General from India had awakened at the Venice Conference by stating that in Bombay the poor lived in chawls—*i.e.*, large lodging-houses—to the number of a thousand and upwards in each chawl, and the light of day could not enter. Surely the Surgeon-General never could have made such a statement at Venice. Such an idea is monstrous. I have known the streets and lanes of Bombay intimately for the last five years, and I state, without any fear of contradiction, that such places do not exist. Last November I visited, as one of the plague-searching party to find out concealed cases, a number of these chawls, and in only one did I find a single room where the sun could not enter, as there was no window, and that on the ground floor, and no one need have lived there. No doubt there is room for improvement in many of the chawls, but some are very well built for light and air. It must be remembered that in Bombay the difficulties are very great. We have to face there the largest population per square mile of any city in the world. As regards one's personal comfort, having visited for seven years the lowest poor in the cities of Bombay and Calcutta, I prefer doing so to visiting the same class in the large cities of England.

Sir, for the credit of the Government and the honour of Bombay I am pleased to be able to make the above statement. It seems not right, when the Government of India is bearing such a tremendous strain as at the present time, that any misapprehension should be allowed to gain currency which may in any way add to its burden.

ARTHUR H. BOWMAN (Rev.),

Late Incumbent Girgaum and Government Chaplain
Byculla Gaol, Bombay.

Church Missionary Society,
Salisbury-square, E.C.
February 17.

ELEVENTH ORDINARY MEETING.

Wednesday, Feb. 23, 1898; Sir GEORGE KEKEWICH, K.C.B., Secretary to the Committee of Council on Education, in the chair.

The following candidates were proposed for election as members of the Society :—

Bruce, Major Robert N. D., Messrs. Vickers, Sons and Maxim, Limited, Sheffield.

Couper, John Duncan Campbell, B.A., 80, Grosvenor-street, W.

Craggs, C. H., Elm-tree-house, Macaulay-road, Clapham, S.W.

Evans, P. F. Sparke, J.P., Trimore, Clifton Down, Bristol.

Hadfield, Frederick N., P.O. Box 211, Durban, Natal, S. Africa.

Pestonjee, Nowrojee, Ahmedabad, India.

Remington, John Stewart, Dromore, Milverton, Leamington.

Worth, Frederick Gouner, 63, Queen Victoria-street, E.C.

The following candidates were balloted for and duly elected Members of the Society :—

Birkin, W. A. G., Villa Victoria, The Park, Nottingham.

Collins, James Tertius, J.P., Churchfield, Edgbaston, Birmingham.

Jardine, Sir John, K.C.I.E., 34, Lancaster-gate, W. Kennedy, James, 15, Willow-road, Hampstead-heath, N.W.

Lamb, Edmund G., M.A., Old Lodge, Salisbury.

Spargo, Edmund, 3, Cable-street, Liverpool.

The CHAIRMAN, in introducing Mr. Brudenell Carter, said the Education Department were greatly indebted to him for his inquiries into the eyesight of children in schools—in fact, he might be called the eyes of the Department in that matter, and he had placed his services at their disposal without any honorarium or remuneration whatever.

The paper read was—

THE EYESIGHT OF CHILDREN.

BY R. BRUDENELL CARTER, F.R.C.S.

A Society, which has for the sphere of its operations the whole of arts, commerce, and manufactures, can hardly be indifferent to the welfare of that part of the human organism which, more perhaps than any other, is essential to the proper cultivation of all these fields of human activity. The eyes of children must usually be ranked as the most precious of their possessions, and as possessions which, both in the individual and probably in successive generations, are capable of being improved by cultivation and of being injured by exposure to unfavourable conditions. It will be my object, as far as may be possible within the limits of time available for the purpose, to direct your attention to the chief agencies which, during the time of childhood, have been found to be either favourable or detrimental to vision, and to show in what way the former may be encouraged, and the latter may be obviated. For this purpose, a brief account of the eye as an instrument seems to be an essential preliminary.

In its general characters the eye resembles a photographer's camera. It is a sort of box, spherical in outline, formed of a strong and dense external tunic, blackened or at least darkened interiorly, presenting in front a

transparent window, called the cornea, coloured diaphragm or stop, the iris, with central opening for the admission of light called the pupil, and a bi-convex lens, which forms, at its focal length, a reduced and inverted image of the objects of vision. This image falls upon a membrane called the retina, which corresponds to the ground glass screen of the camera. If we take the eye of a freshly killed animal, and carefully peel off the investing membrane at the back, so as to expose the retina, and then turn the front of the eye towards the landscape, we shall see a inverted image or picture of this landscape in the eye, just as we should see it on the glass of a Kodak when selecting a point of view for a picture. The picture in the eye when this is in proper focus, is better than that of an ordinary camera, because, on account of the curved shape of the eyeball, all parts of the retina or screen are at the same distance from the lens. In the camera, as we all know, the centre of the flat glass screen is nearer to the lens than the marginal parts, and hence although the defect is rendered practically unimportant by various mechanical contrivances, a picture which is centrally perfect is less well defined at its boundaries.

The retina itself is an exceedingly complicated nervous structure, of which the most important portion, as far as we are now concerned with it, is an infinitely fine mosaic formed by the terminations of the innumerable fibres of the optic nerve. The closely-packed elements of this mosaic are brought by reciprocal pressure into hexagonal form, and each tiny hexagon is the terminal surface of a fibre which conducts the visual impression made upon it to the brain. How this conduction is effected, or how the merely physical picture produced within the eye is translated into consciousness, we do not know. What we do know is that clear definition in the picture is essential to clear perception by the mind. If we look through a telescope which is out of focus, the retina receives a blurred image and from this the mind obtains only a correspondingly blurred idea.

The production of a clear image upon the retina, like the production of a clear image in a camera, depends upon the simple condition that the lens, by which the image is formed, shall be of the right strength, and shall be situated at the right distance from the screen. The focal length of a lens is measured by the distance from it at which parallel rays of light, such as proceed from distant objects, are

brought to a point in such a way as to form a picture; and this is called its principal focal length. When a camera is directed to distant objects, its lens should be its own focal length from the screen. In this condition, if the camera be turned to a near object, the image of that object will be blurred, and only be rendered clear by increasing the strength of the lens, or by increasing its distance from the screen. In some cameras the lens is moved to and fro by a serew; in others, especially in some of the modern "snap-shot" forms, extra lenses are provided, to be put over the fixed one and to increase its strength in proportion to the nearness of the near object. Whatever is done, the principle is the same. If the distance between the lens and the screen be invariable, the lens must be stronger, that is, must have a shorter focal length for a near object than for a distant one. We shall presently see in what way these considerations become of practical importance.

We take, as the typical human eye, one which is called "emmetropic." The word simply signifies to be *in measure*, or to be of correct proportions, and it is applied to a state in which the actual length of the eyeball, from front to back, is such that the position of the retina precisely corresponds with the focal length of the lens. In such a condition, of course, when the passive eye is directed towards a distant object, a perfectly clear and defined image of that object is formed upon the retina. If the eye, remaining unchanged, were then directed towards a near object, the image of that object would be blurred and indistinct. The distance between the lens and the retina is practically invariable, and therefore, in order to obtain a clear image of the near object, the strength of the lens must be increased, just as, in a snap-shot camera, an additional lens is provided to be placed over the permanent one. In the eye, the change is effected by muscular effort. The details of the mechanism are open to some doubt, but the general effect is that the lens, when the eye is directed to a near object, is compressed in such a manner as to become more convex, and therefore stronger. The act is called the act of accommodation, and we are said to "accommodate" for the distance of the near object, which clearly, through the sense of vision, determines the amount of the effort; this has to be greater and greater, as the object is brought nearer and nearer. If you take a piece of stretched net, and hold it

between the eyes and a printed page, you will see that, if you try to read the page, you can do so, although dimly conscious of the net as an interposed film. If you increase the accommodation, so as to look at the net, and to see the threads of which it is composed, the letters will no longer be legible. For them the accommodation will be in excess of what their distance requires; and, if the eyes be again directed to them with clear vision, the accommodation will be less than that which the fibres of the net require. The essential characteristics, therefore, of the emmetropic, or, as it is sometimes called, the normal eye, are that it obtains clear vision of distant objects when in a state of rest, and that it obtains clear vision of near objects by virtue of an effort, which increases in degree as the object approaches. For every such eye there is a limit to its power of accommodation effort, that is to say there is a near point, nearer than which clear vision cannot be obtained. This near point is at its nearest at about eleven years of age, and it slowly recedes from the eye, in consequence of gradual diminution of the power of accommodation, as life advances. Elderly people, before they begin to use spectacles for near objects, such as print, find it necessary to hold these objects farther and farther from the eyes in order to see them distinctly. To the distant vision of emmetropic eyes there is no limit, other than such as may be imposed, in a way presently to be described, by the size of the object in relation to its distance, or by the interception of the light proceeding from it by the atmosphere. On a clear night, for example, emmetropic eyes obtained distinct vision of the markings on the surface of the moon.

The emmetropic eye, the eye that is "in measure," may be further described as a well-proportioned eye, the parts of which are in harmonious relation with each other; and, like well-proportioned organs in general, it is of greater endurance, and better working capacity, than one in which correct proportions are not maintained. Its correctness depends, you will remember, upon the identity of two distinct measurements, the distance from the optical centre of the eye at which the visual image is formed, and the distance from the same point of the screen on which the image is received.

If we assume the distance at which the image is formed to be invariable, it will at once be evident that the other distance, that of the position of the retina or screen, may vary in

opposite directions by being too near or by being too far away, and that we thus obtain two distinct and opposite types of disproportion, which will severally produce different effects.

We will take, in the first instance, the form of disproportion in which the screen is too near, or in which, relatively to correct proportion, the eye is flattened, or too short from front to back. In the diagram on the wall, the dark line represents a section of an emmetropic eye, and the inner dotted line represents a section of such an eye as I am now describing. The late Professor Donders of Utrecht, by whom this condition was discovered, called it hypermetropia, or over measure, a nomenclature which would indicate that the disproportion was on the side of the image forming rather than that of the image receiving apparatus. As far as we can ascertain, however, the contrary is usually the case, and hypermetropia is really what I much prefer to call it, flat-eye. In point of fact, the eye is under developed, undergrown; and we shall see presently that this under development or under growth sometimes applies not only to the bulk of the organ as a whole, and to the comparatively small distance between the optical centre and the retina, but also to the formation and receptive power of the nerve filaments of which the screen is composed.

I have already mentioned that, if we take the eye of a recently-killed animal—that of a bullock, from its size, is convenient for the experiment—and expose, without injuring, the retina by the careful removal of a portion of the external investing membrane, we shall, on turning the front of the eye towards any object, such as a landscape, see a clearly defined inverted image of the landscape on the exposed retina, precisely as if it were the ground glass screen of a camera. If we were to repeat the experiment with a flat eye we should see upon its retina, instead of a defined picture, only a blur, or a picture out of focus; while, if we held a screen a short distance behind the retina, we should obtain a distinct picture upon that. In other words, the flat eye, when passive or at rest, has no clear vision of anything, and it only obtains clear vision by an effort of the same kind as that which is made by a normal eye when directed to a near object. The eye cannot lengthen itself or increase the distance between its optical centre and its screen, and it is compelled to overcome its faulty shape by an exercise of accommodation, that is, by increasing the curvature, and

so the optical effect, of its internal lens. Such an effort being required for distant objects must manifestly be increased for near ones. The effort is called forth by imperfect seeing, and can hardly be described as voluntary, so irresistible is the desire to see. It may, of course, be increased and continued by voluntary effort, but it can seldom be completely relaxed, and the result is that the flat eye is never at rest, but is working, when directed towards distant objects, in the same way as the normal eye when directed to the print of a book. The amount of effort necessary for good vision will depend, of course, upon the degree of flatness, and the power of maintaining it will depend upon the strength and tonicity of the muscles by which the necessary work is accomplished. When the flatness is not excessive in degree, and the muscles of accommodation are strong, the proprietor of flat eyes may suffer little or no inconvenience from them; but, where the opposite conditions obtain, the distress incidental to sustained visual effort may be so great as to involve incapacity for many occupations, and sometimes an increased liability to disease.

We next come to the opposite condition, in which the distance between the optical centre of the eye and the screen is too great instead of too small, and in which the eye, instead of being unduly flat, is unduly elongated from front to back, as shown by the outer dotted line in the diagram on the wall. This elongated eye is the physical cause of what is properly called short-sight. If we were to expose a bit of the retina of such an eye, and turn the front of it towards the landscape, we should obtain only a blurred picture, and, if we were to hold a ground glass screen behind the retina, instead of better definition, as with the flat eye, we should only obtain increased indistinctness. But if, instead of directing the eye towards a distant object, we were to direct it towards one sufficiently near, we should then obtain a clear image; and, in this way, we should repeat the daily experience of short-sighted people. They can see perfectly things which are sufficiently near, but they can only see indistinctly things which lie beyond some definite measureable distance, which varies according to the degree of elongation of the eye, and is the far point for each short-sighted person. The normal eye, you will remember, has no distant limit, but only a near limit; while the short-sighted eye has a distant limit, a foot, it may be, or a yard, beyond which it cannot see clearly

without optical assistance. Moreover, unlike the flat eye, it can do nothing to overcome its own defect, which would be aggravated, instead of being improved, by an effort of accommodation. It is only an apparent exception to this statement that the short-sighted see better by half closing their eyelids into a chink; this not being an adjustment of the eye itself, but only a use of the lids as an external apparatus for cutting off the more external portions of the pencils of light. The habit of partial closure of the lids has given rise to the word *myopia*, from the Greek, signifying to close the eyes, by which short-sight is commonly designated. If we were to follow the lines of nomenclature adopted by Donders, the right term would be *hypometropia*, but, for myself, I prefer to say short-sight, just as I prefer to say flat-eye.

The evils attendant upon short sight are much greater and more important than those of flat eye, but fortunately the condition itself is far less common, although still much more so than could be desired. Flat-eye is obviously a matter of formation, often, no doubt, of inherited formation; and in favourable circumstances it often diminishes during growth, the eyes attaining better proportions than they originally possessed. Short sight, on the other hand, appears usually to depend upon yielding or stretching of the ocular tunics under the stress of work, and to be due rather to an inherited weakness of these tunics, involving liability to stretch, than to an originally faulty shape of the eyeball. It almost follows that short sight is very liable, under unfavourable conditions, to increase in degree with some rapidity; and when it does so, the strain thrown upon the internal membrane of the eye is very apt to occasion absolute disease. Moreover, it must be remembered that a short-sighted child grows up with but a limited knowledge of its environment. It cannot see clearly, let us say, any object which is more than three feet distant from its eyes. This means deprivation of nearly all the beauties of nature and art, incapacity to perceive the expression of the human face, a sapping of the faculty of observation at its very root, and, generally speaking, a consequent incapacity to take large or general views. The mind is fastened upon the details which alone the eyes can see and appreciate; and experience sanctions the extension of the expression "short-sighted" from the eyes to the judgment. To the short-sighted child the external world presents comparatively few attractions, and it is

usually his delight to be coiled nose and knees together in some half-lighted corner, absorbed in a book.

The evils of both these chief malformations of the eye are, as a matter of course, largely dependent upon their degree, and this is measured in every case, by the strength of the lens which is required to correct them. For every flat-eye there is a convex lens, and for every short-sighted eye there is a concave lens, which will render the malproportioned organ emmetropic, which, in the flat eye, will bring forward the focus of its own optical apparatus, and in the short-sighted eye will push back that focus, so that in both cases it falls upon the retina when the eye itself is passive. We use, as a unit of measurement, a lens, the focal length of which is one metre, and we call this a dioptré. Flatness of less than a dioptré and a half, or two dioptries, is scarcely felt as an inconvenience by strong and healthy people, and degrees above four or five dioptries are seldom met with. In short sight anything under two and a half dioptries would be called slight or moderate, and anything above five or six would be called high, but cases running up to twenty or more dioptries are occasionally met with. A person with five dioptries of short sight could not read small print at a greater distance from the eyes than eight inches, and a person with ten dioptries could not read it at a greater distance than four inches. It used to be said of a late statesman that when he read his eyelashes could be heard to scrape on the paper.

We may now proceed to consider the determining causes of the quality or acuteness of vision, and the way in which this quality is estimated, either in a normal eye, or in one which is rendered normal by the addition of the lens which corrects its flatness or its short-sight. In order that an object may be clearly seen, it is necessary that the image of it formed upon the retina should be of a certain magnitude; and the magnitude of the image depends partly upon the size of the object and partly upon its distance. It is said to subtend a certain visual angle; the visual angle being that which is formed by two lines proceeding from the extremities of the object to meet at the optical centre of the eye, just behind the opening of the pupil. The rays of light, proceeding from these extremities, meet and over-cross within the eye at its optical centre, *O*, a point usually about 17 millimetres from the retina. In their further course over those 17 millimetres they diverge, and thus

they finally include a retinal area the size of which is governed by that of the angle at which they meet. In the diagram on the wall the line, C D, represents an object placed near the eye. The rays of light proceeding from C and D, the extremities of the object, meeting at O, and including the large visual angle, C O D, proceed to fall upon the retina at the points, *c*, *d*, and to form between those points an image of corresponding magnitude. The line, A B, represents a smaller and more distant object, and the smaller visual angle, A O B, leads to the formation of the smaller retinal image, *a*, *b*, while, to show that the distance of the object, as well as its size, is a factor in determining the magnitude of the retinal image, the line, A' B', represents an object larger than A B, but so much more distant from the eye that the angle, A' O B', is equal to the angle A O B, and the retinal area covered by the image is in both cases the same.

Now, the word vision, or seeing, when employed in its physiological sense, does not mean the mere perception of the presence of an object, but the recognition of its characters. I could easily remove these letters [shown] to a distance at which they would be perceptible as black smudges, but would no longer be visible as characters which you could read and name; and at such a greater distance, you would be correctly said to "perceive," but not to see them. You would perceive objects, but you would not be certain what they were. Defining vision as the power of recognising the essential characters of the object, it is found to require, for such letters as these, that each letter as a whole should subtend a visual angle about of five minutes, while the parts or limbs each subtend to a visual angle of one minute. The power to see, under the specified angles, is defined as normal vision, and is the accepted standard of the Royal Navy; but there are many people who see better than this, that is, who can see under a still smaller visual angle. There are certain objects which, on a clear day, can be perceived at great distances, and people talk about "seeing" them, but they are using the word in its popular and not in its exact sense. A flagstaff is such an object, and may often be perceived as a vertical dark line at a great distance. But, if there were two flagstaffs placed side by side, with an interval between them equal to the diameter of each, the far distant observer would not be able to see the separateness of the two, although he might perceive that the dark line seemed

thicker than usual. In the same way we perceive many stars as points of light somewhat diffused by atmospheric dispersion, but we cannot see that some of them are double until we obtain a larger image by the help of a telescope. We cannot see the separateness of the two bodies by which the spot of light is constituted. Now, the power of seeing separateness, of seeing, for example, the two intervals which separate the three horizontal limbs of the letter E, only exists when the image is of such a size that at least one entire retinal hexagon, the termination of one fibre, is left untouched by the images of the limbs, and stands clear and unaffected between them. It follows that what is called the "acuteness" of sight, the power of distinguishing the component parts of a distant object, and of recognising its characters, even when a perfect retinal image has been formed, must depend for its degree upon the fineness of the retinal mosaic, upon the absolute smallness, that is, of the diameter of the individual hexagons of which that mosaic is composed. If the hexagons are comparatively large, the image is coarse, a larger image, that is to say, a larger or a nearer object, will be required in order that unaffected hexagons may be left between the intervals between its component parts.

In 1895, I instituted an examination of the sight of a large number of children in the London Board schools, and, as a preliminary measure, 8,125 of these children, in 25 schools, or 16,250 eyes, were tested as to acuteness of vision by their teachers. No doubt there were some inaccuracies, but I have reason to believe that this part of the examination was, on the whole, carefully and well conducted. A disc like this was hung up in a good light, and each child was made to stand at such a distance from it that the third letter of the series of four was seen under that visual angle of five minutes which satisfies the requirements of normal vision. By turning the disc, the proposed letters could be varied. Each child had first one eye covered, then the other, and was told to read down the letters from the top. Out of the 8,125 children, there were only 3,181, or 39.15 per cent., who had normal vision with both eyes, and the cases of normal vision with one eye and subnormal with the other were an insignificant minority; so that, roughly, of London school children between the ages of 8 and 13, nearly 60 per cent. do not see so acutely—that is, as well and as sharply—as they ought to do. To this part of the subject, which seems to me to be of national importance, I will presently return.

It was my original intention personally to examine all the cases of subnormal vision, but the time required for the purpose was so great, and the difficulties of the undertaking were, in many respects so serious, that I was only able, with the assistance of my friend, Mr. Ackman, to examine 1,448 children. Of these I found flat-eyes in 61 per cent., and short-sight of both eyes in 14.3 per cent. Each of these conditions will require a brief discussion. It must be conceded, in the first place, that flat-eye probably exists in a considerable proportion of the children whose sight was reckoned by the teachers as normal; and to this addition, as I have said, I do not attach a great deal of importance, except in so far as it may be an evidence of general underdevelopment. I speak on this question from knowledge of many cases in which, in persons of good health and good muscular development, the eyes are to the extent of as much as two dioptries, and have been used diligently, without suffering inconvenience, and without any need for the use of spectacles until about the ordinary age for such assistance. On the other hand, there are many persons in whom even a small amount of flatness gives rise to troublesome symptoms; a question having more relation to the general incapacity for nervous and muscular work than to the actual formation of the eyes themselves. In other words, some people are able easily to overcome a defect which in others is liable to become a cause of incapacity. When flat eye is extreme in degree, or when it occurs in feeble children, the effort of correcting it becomes fatiguing, and, after a short period of reading or of other close work, the effort is relaxed, with the result that the vision becomes misty and obscure. The little sufferers then rub their eyes, often with dirty fingers, and thus aggravate them still more; while the efforts call for an additional blood supply and renders them flushed and angry. Headache often follows, and, at the best, the attention of the child is diverted from the tasks to the bodily aches and pains. Sometimes the child finds it more easy to read by bringing the page very near to the eyes, the increased magnitude of the retinal image being more than a compensation for the greater strain on the accommodation, and this tendency has often been increased by bad school fittings, such as faulty desks and desks, which have rendered it difficult for the pupils to maintain a correct position of the head and of the body, and have compelled them to stoop more or less obliquely to their work. Faulty positions are hurtful

in three ways: first, by interfering with the circulation, that is, with the proper passage of the blood between the heart and the brain; secondly, by promoting contraction of the chest and spinal curvature; and, thirdly, by calling upon the eyes for undue convergence, and for positions in which their combined action is rendered difficult. The first two are obvious evils, upon which I need not dwell; but the third, the undue approximation of the eyes to their work, is apt to cause the flat eye to pass over into the short-sighted one, a change of which the researches of Dr. Risely in Philadelphia have brought to light many examples.

The apparatus here exhibited was constructed for the purpose of showing the actions of the muscles by which the eyes are moved, so as to work in harmony with each other. These actions are somewhat complicated, and give rise to many considerations, with only one of which I need trouble you on the present occasion. The centres of the eyeballs being roughly $2\frac{1}{2}$ inches apart, the line of visual direction—the line along which each eye looks in order to see the object towards which it is directed—varies in its course with the nearness of the object. In looking at an infinitely distant object, such as a star, the lines are parallel, and in looking at a near object, they are rendered convergent; but this convergence does not become manifest until the object is within about 20 feet, after which it rapidly increases, and attains its maximum when both eyes are directed towards an object, such as a printed page, which is held only a few inches from them. It is necessary for single vision with the two eyes that the two images should fall on corresponding points of the two retinæ, and therefore, in all near vision, accurate convergence must be steadily maintained. This is effected by the action of two muscles, each of which is attached to the inner side of the external surface of its corresponding eyeball, and by its other extremity to the skull. The muscles, so to speak, pull the eyes round, not altering their actual position within their orbits, but causing them to rotate on their respective centres. Now, I think it will be obvious that a continued convergence effort to a near point must not only be fatiguing to the muscles by which it is accomplished, but that it must also cast a considerable strain upon the tunic or outer covering of the eye at the point where the muscle is inserted. It has long been recognised that this strain may positively stretch

the eyeball, and may cause it to yield at a point nearly opposite to that at which the traction is exerted, thus rendering it longer from front to back, and, therefore, in other words, rendering it short-sighted. Emmetropic eyes, generally speaking, will bear without injury any amount of convergence which is likely to be required from them; but it is highly probable that short-sighted eyes, as a rule, inherit a weakness of the external tunic, and are, therefore, predisposed to stretch and yield under the influence of muscular action. Differences of opinion still exists, among very good judges, with regard to the precise method of production of the steady increase in the degree of short sight which is so often witnessed, and also with regard to the passage of flatness into short sight; but there is no question but that both these changes, if not directly caused, are at least greatly assisted by over-convergence, and also by the many faulty positions of the head and body which flat-eyed or short-sighted children constantly assume, either on account of badly-arranged seats and desks, or to get more light, or in some way to facilitate the employment of the eyes in unfavourable circumstances and surroundings. To show the sort of effect that may be produced, I will put upon the screen two pictures photographed from actual school-rooms, one of which was badly lighted from the right of the workers, while the other is properly lighted from the left. You will see that in the former no child is sitting straight, but that all are striving by various strange attitudes to compensate for the artificial difficulties under which they are placed, and you will readily imagine that the undue approximation of the eyes to the work, and the disparate positions of the two in relation to it, must call upon the muscles for irksome and irregular contractions. Now these irregular contractions, it has been shown by many observers, are fertile causes of that extension of the eyeball from front to back which is the actual physical cause of increasing or progressive short-sight, and also the cause of the acquired or secondary short-sight which is a not uncommon sequence of the higher degrees of flatness, or of any degrees of flatness if the muscles which should counteract it are weak and irritable. If the eyes are compelled to work under thoroughly unfavourable conditions, they will inevitably suffer in some degree. It is the duty of school managers to see that such conditions do not obtain in the schools

themselves, and it is the duty of parents to see that they are obviated, as far as possible, at home. Wherever home study is required the managers should, I think, see that parents are cautioned with regard to the conditions under which alone it should be carried on. A chair and table which compel the assumption of a faulty position will be quite as hurtful at home, if they are in use there, as they would be in a school, probably more hurtful because the home light is, on the whole, less likely to be sufficient than that of a school.

It is obvious that the educational arrangements of a great community must be mainly governed by the requirements of the majority of the scholars, and that the responsibility of claiming provision for exceptional requirements must rest mainly with the parents of such children. But, if we consider how many of these parents are themselves ignorant of the existence of exceptional requirements, I think it is not too much to ask that they should be assisted by school authorities in discovering them. Very few people have any exact knowledge as to what their child ought to be able to see. Most parents would not know about how far a child of ten should be able to run or to walk, how high he might be expected to jump, what weight he might be reasonably asked to carry. Not one in a thousand could say what the child ought to be able to see, or what sized letters he ought to be able to read at a given distance. I think that it should form part of the business of schools, in this respect, to educate parents as well as children. I think the vision of every child brought to school should be tested at admission, and entered in a register. Done as a matter of routine, the testing would occupy a minute a child; and, in every case in which the vision was subnormal, the parent should receive official information of the fact on a printed form to be issued by the teacher, and which should recommend the obtaining of skilled advice as to vision before schooling was proceeded with. If this were done, the matter would no longer be suffered to drift, as it too often is at present; or, at least, the parents would be unable to plead ignorance. At the numerous ophthalmic hospitals which are open to the poor, and from private practitioners in the case of those who were better off, parents would learn under what conditions the education of their under-sighted children could most profitably and most safely be conducted.

I would have only themselves to blame these conditions were not secured.

In my inquiry, I am glad to say, so far as it ended, went to show that both the higher and more injurious forms of short sight, and the higher and more injurious forms of flat-sight, were less common in the London schools than they are said to be in many other capitals; and that, on the whole, the state of our children in these respects might be regarded as satisfactory. The unfavourable condition with which I was chiefly impressed arose from the defective character of the vision of many healthy and approximately well formed eyes; a defective character which appeared to me, as a matter of high probability, to be largely due to town surroundings, and to their influence upon the work which the eyes are habitually called upon to perform. As mentioned in my introductory observations, only 5 per cent. of all the children examined were found to be in possession of normal vision; that is, to be able to distinguish detailed characters seen under a visual angle of five minutes.

My interpretation of this prevailing subnormality of vision is that it is mainly attributable to the surroundings and conditions of living of children, although not specially to any which prevail in the schools. The diagram on the wall represents the hexagonal arrangement of the nerve terminations in the central or most sensitive seeing part of the retina, terminations so minute that, in an average adult eye, there would be about 7,000,000 of them in this small central area, and about 130,000,000 in the whole of the retina. Each of these terminations is believed to be functionally indivisible, and to respond as a whole to every impression which it receives. Let it be supposed that the letter **E** represents the image of such a character, as it is cast upon the retina, and that it is of sufficient magnitude to leave a wholly unaffected hexagon between the upper and lower, and again between the lower and upper, limbs of the letter. By means of these unaffected hexagons, which receive no impression of blackness, the existence and shape of the white interspaces will be distinguished; and if the image were only a little smaller, as it is, so that the horizontal limbs encroach ever so little upon the intervening hexagons, then no impression of interspaces will be perceived, and the character will be only a blur. It is therefore manifest that the acuteness of vision must depend largely upon the actual magnitude of the hexagons; that, if they are small, vision

will be more acute, and that, if they are large, vision will be less acute. The whole history of human development leads to a belief in the existence of a close interdependence between the quality of function and the mode of its habitual exercise; and I think it cannot be doubted that the habitual use of the eyes in looking at objects which are on the verge of visibility will have a decided tendency to promote the growth of nerve fibres, and thus to increase the power of the faculty to which they are subservient. Now the visual power of London children is not cultivated by their environment. They see the other side of the street in which they live, and the carts and omnibuses of the thoroughfares, seeing them, as a rule, under a visual angle of five degrees rather than of five minutes. They scarcely ever have the visual attention strongly directed towards any object which it is difficult to see, or which subtends a visual angle approaching the limits of visibility; and hence their seeing function is never exerted, or at least is not habitually exerted, to anything like what should be the extent of its powers. The case of the country child is widely different. He has before him an expanse of landscape, presenting numerous interesting objects under visual angles which are rendered small by distance. He finds attractions in every hedge-row; flowers, insects, birds, nests, many of them disguised by their resemblance in colour to their surroundings, and requiring sharp and trained sight in order that they may be readily distinguished. His eyes are exercised beneficially in his daily life, and his vision, as far as I have been able to examine into the facts, is found somewhat to exceed the very moderate standard of normality, just as that of the city child is so often found to fall below it.

There are many other respects, besides vision, in which the conditions of city life are found to act, or rather would tend to act, prejudicially upon physical development; and, in some at least of these we have seen, of late years, great and successful efforts to counteract the tendency. If we may accept Paley's definition of education, as comprising every preparation that is made during our youth for the sequel of our lives, I think that among these preparations, and as part of education, should be included an effort to cultivate the art of seeing, and to improve what I believe may be rightly called town vision. It must be remembered that the only visual efforts which are injurious are those which are directed to

near things, and which therefore involve strain of the accommodation and of the muscles which effect convergence, while all difficult seeing of distant things falls within the category of those efforts by which the powers of the organism making them are increased. Children in whom defective sight is attended by defective shape of the eyeball should be supplied with spectacles of the kind required for the correction of the individual defect; and, when so supplied, they should take part with others in the description of objects so placed as to subtend small visual angles, letters or sentences, it may be, of proper proportions, seen from the opposite side of the room, or pictures containing details, some of which would not be recognisable by subnormal vision. The training of the eyes is, I think, quite as important as any form of physical drill, to which much time is already devoted, and the two things might without much difficulty be combined. Moreover, as I have often said before, I should like to lay stress upon the desirableness of giving a place to excellence of vision among the various physical qualifications which are habitually tested by competition, and for which prizes are awarded. A seeing contest would seem strange while the idea was new, but it would be just as reasonable as any other, and probably more useful than some. It would tend to diffuse a knowledge of what seeing ought to be, and would bring hundreds of eyes under training which they would not otherwise receive, and by which they could not fail to benefit. Not only would individual sight be improved to some extent, but a finer formation and an increased sensitiveness of the nerve fibres of the retina would be likely to descend to offspring, and thus to be perpetuated in the race. The Tartar of Siberia, whose unaided eyes enabled him to tell Arago of the occultation of Jupiter's third satellite, or the South American guide, who described to Humboldt, across a valley of the Andes, the position and order of march of a party which the great traveller could only see with the help of a telescope, had no better basis of visual formation than exists among ourselves. They were simply the descendants of people who, for generations, had been dependent for safety or for sustenance upon the acuteness of their sight, and in whom that faculty had in consequence become developed, just as, in the converse of these conditions, it has fallen to somewhat low estate among many of ourselves.

DISCUSSION.

The CHAIRMAN said he fully agreed that subject was one of national importance. Mr. C. spoke of town sight and country sight, but intimated that he had not extended his observations very far into the state of the children in the country districts. It would be very interesting if at some future time he could do something of that kind, especially as it seemed to indicate that, on the whole, town sight was bad, or short, and country sight long, as spoke of certain people who from having to strain their sight for long distances through many generations had acquired the habit of long sight. He thought it did not require much time to acquire a certain amount of long-sightedness. Judging by his own experience he remembered very well in his youth going out stalking in the Highlands, and when he first went out the stalker would take a glass and he could see a stag on the side of a hill perhaps ten miles off, where he could see nothing; but after going out continuously for a month or more he found he could see nearly as well as the stalker. With reference to the incidence of the light in schools, the Education Department always recognised that the light ought to fall on the desks from the left, and that condition could generally be obtained. It was insisted upon before the approval of the plans; but what could be secured were proper desks and seats, which enabled the child to sit so that the eyes were at a proper distance from his work without undue effort. He considered that in order to ensure that, the edge of the seat should come flush with the edge of the desk, there was generally a considerable gap between them which caused the child to bend forward. Mr. Brudenell Carter was on the Committee of the Education Department which was considering this question, and he hoped in a short time would make a report. They could suggest anything which could be carried out generally, it would be of great national advantage. The use of spectacles in very early life, whatever might be later, was not only inconvenient but becoming, and he hoped that as a nation we should spare the necessity of using them.

The Rev. F. SYNGE (Chief Inspector of Schools) said he had already read with interest Mr. Brudenell Carter's report on school sight, and had also had the advantage of a report on the schools in his own district made since. It was suggested that a register should be kept of how children could see when they first came to school, and he believed the teachers were perfectly capable of estimating whether each child's sight was normal or subnormal, and the oculist who followed and examined the children's eyes more in detail could indicate what were the defects, and how they could be met. All that was easy; the hitch came afterwards. A large proportion of the children were found to have serious defects of sight, and they told they should obtain advice, hospitals where advice could be obtained gratis being pointed

t a short time afterwards when he went into one of these schools he found on inquiry that not a single child had been to a hospital or a doctor for advice. The difficulty was to overcome the apathy of the parents to these defects. Possibly some of the unwillingness to seek such advice would be overcome if the practice of putting drops into the eye before examination could be dispensed with. This was not serious, as it was slightly unpleasant to the child, and might frighten it and the parents, and if the examination could be done without it might be an advantage.

Mr. G. R. BAKER said there was a simple instrument named the optometer, which was quite sufficient for a preliminary examination without the use of any drops to dilate the pupil. With regard to the fitting of school-rooms he could say from an acquaintance with a large number of teachers that their eyes suffered from defective light, whatever the children's did. He had tested a great number of teachers, and found their sight much below the average. There was no doubt that a great deal of improvement might be effected by training, for he found that military and naval men who would ordinarily be described as short-sighted, by special training had become normal-sighted, and were able to see well. This bore out the experience of the Chairman.

Mr. C. KRALL wished to put a question as to the possibility of young children whose sight was defective wearing glasses continually. He had been short-sighted from his youth, but did not begin to wear glasses until he was 16 or 17; and from that time his sight had become worse continuously, so that he had to wear stronger and stronger glasses. Therefore when he found one of his children short-sighted, he naturally felt some hesitation about letting her wear glasses, but his schoolmistress suggested. He took her to a doctor who examined and prescribed glasses, and said she should wear them continually, but he felt some doubts about it from his own experience.

Mr. HENRY TRUEMAN WOOD remarked that all the results of Mr. Brudenell Carter's, so far, appeared to have been obtained from inquiries in elementary schools, and he thought it would be very instructive if he could extend his observations amongst children in the more well-to-do class. At the great public schools, such as Eton and Harrow, the masters would probably grant facilities for the examination of some of the junior forms, or it would perhaps be better if an investigation could be made in some of the preparatory schools from which boys went to the great public schools, where the children were better nourished, and lived under more generally favourable conditions than those attending the Board schools. With regard to the school fittings, the elementary school children were far better off than the children of the wealthier classes. He well remembered that at Harrow, the fourth form room

had no desks at all; there were seats, but the boys had to write on their knees, and in the other rooms no consideration at all was paid to where the light came from, sometimes it was from the back, sometimes from the front, or right or left, as the case might be. He apprehended it was the same now, except in the case of any new rooms which might have been built recently. With regard to long sight being obtained by practice, he believed Mr. Carter would say that was impossible; what really happened was that the owner of the eye learned what to look for. After the Chairman had been stalking for some time he got to know what the head of a stag looked like at a long distance, and was thus able to discern it. He did not think there was much authority for the statement that the eyes of savage races were any better than our own. The sight of the Tartar who saw the satellite of Jupiter would be exceeded by that of the late Mr. Dawes, a country minister, who could see, with the naked eye, double stars and many other celestial objects with perfectly telescopic vision. Men who had been on shooting expeditions in foreign countries often said that they did not believe the eyes of savages were superior to their own, only they knew what to look for, and saw it sooner, just as a sailor would see a ship long before a landsman. But Englishmen with normal sight soon got as skilful as native hunters in this respect. In the same way he knew from experience that a person accustomed to play golf would see where the ball went much better than a man with much better sight who did not practice the game.

Mr. J. I. TRACY said he had some knowledge of Board schools in the district of Walthamstow, and he noticed that a great many of the teachers—more men than women—had to wear glasses, many of them being comparatively young. How far that was due to bad light in the schools or to over-straining of their eyes, especially at night, he could not say; but it was a very serious matter. Defects in lighting might, no doubt, partly account for it, for he knew of some schools where the teacher had to face the direct light from the south, and the scholars had to receive most of the light over their shoulders. Originally he had excellent sight himself, but by too severe a strain, having to look at small bright objects by gas-light for many years, he found his sight failing, and thought he should lose it. However, he considered that if he gave them entire rest for a time they would recover, and by adopting this plan he might say that he had now very fair sight for his age. He was sorry to see the increasing number of quite young children who wore spectacles, most of whom seemed to be near-sighted, and he feared they were being made permanently short-sighted.

The Rev. C. D. DU PORT (Chief Inspector of Schools) said it was not necessary to go to Walthamstow to find instances of what had been referred to by the last speaker. There were cases

in East Lambeth, under the London School Board, where the eyes of the teacher's were much strained by being exposed to the full glare of the light, and only a week or two since he came across cases where children had to work in very large class-rooms where almost all the light came over their shoulders. The Chairman knew perfectly well how difficult it was in some cases to remedy the evil. Where the light has been allowed to come in the wrong way you could not pull down the school and rebuild it, and you could not always even re-arrange the desks so as to make the light fall properly. Though competition was somewhat overdone in the present day he rather liked the suggestion that there should be a competition for eyesight, and thought it would do a deal of good. The teachers were quite capable of carrying out a preliminary examination of the children's eyesight, but possibly some of them in the pressure of other matters did not sufficiently bear in mind the importance of the matter and the way in which the sight might be affected by the conditions of light, position, and so on. If the Education Department would issue a circular calling attention to certain points of detail, to be circulated amongst both managers and teachers, a great deal of good might result. There was another point of more importance in London than the country and that was the question of artificial light. This was not only a vital matter in connection with the night schools but even in the day schools; during the autumn and winter, they frequently—not only in foggy but on dark days—were entirely dependent on artificial light, and the whole system of artificial lighting required reformation.

Mr. W. H. WHITING said he would be glad of any further information from the reader of the paper on the question of training the eye, whether anything could be done in that way to alter the form of the eye, and so cure defects, or whether it only improved the acuteness of vision. As he understood, the advantage of spectacles to short-sighted children was rather indirect, as placing them more on a level with others than actually curative.

Mr. T. R. ABLETT said he should have liked to hear something on the subject of colour blindness, which, according to his experience, was more often found in boys than in girls. The explanation he had heard was that girls were more accustomed to distinguishing colours in their ordinary life, by having to match ribbons, wools, and so on, whilst boys had no such training. With regard to Sir Henry Wood's remarks about the schools of the upper classes, he might say that in girls' schools every care was taken to ensure proper conditions of lighting and desk accommodation. It was well known that the Board schools of London varied very much in structure, mainly owing to the fact that the ground differed in shape and capacity; and the present architect of the Educational Department told him that he had had to do so many impossible things, that he had got quite accustomed to it. He had

been much interested in what was said about the accommodation of the eye, especially as having an important connection with the teaching of drawing and art generally. A picture was seen at a glance, but in a glance the eye could not accommodate itself, and it was one of the difficulties of the teacher to make the student control that accommodation intellectually for pictorial purposes. Every picture had its own focus, and the objects depicted ought to stand out clearly, while all the rest had to be more or less subordinate, according to the distance from the focus.

Mr. APPLGARTH asked if there were any special advantage in having a light of great whiteness, and what were the relative merits of gas light and electric light. In the schools with which he was acquainted abroad, the rooms were all surrounded by a blackboard some three feet high, and some thought this was detrimental to the children's eyesight. The light ought to be adjustable for height, or else in a room many of the children would be of necessity very uncomfortable.

Mr. BRUDENELL CARTER, in reply, said he had only touched the fringe of a great question which bristled with details, which it was impossible to attempt even to deal with. He found that the school-rooms much better lighted than others, but that was not a part of the inquiry which fell within his special province. There were well-known contrivances for measuring the amount of light which fell on the space appropriated to each child, estimating it at so many candles, and that would be done by other members of the committee to which the Chairman had referred. The apathy on the part of parents to which Mr. Sygne referred was not found in all schools. One schoolmistress told him that the result of her preliminary examination had been to send eleven children to the Ophthalmic Hospital the next day, and they were all provided with glasses. Sir Henry Wood had raised a rather difficult question of physiology, whether the improvement of vision which was attained by practice, was really an improvement in the visual organ. As he had said in the paper, the South American or Tartar had no better physical basis to go upon than man, and ourselves, but he did think that in addition to increased knowledge of what to look for, there was an increased sensitiveness to the light coming from the object, which might be gained by practice. As to whether a child should wear spectacles habitually, it was an absolutely individual question, like the question whether a particular person had better take medicine or not. Every case depended on the character and degree of the defect, and whether it was complicated with any disease of the eye, internal or external. In some states of the eye it was desirable that glasses should be worn continuously, and in others they should be worn occasionally; no general rule could be laid down.

regard to the improvement of short-sight, it is physically impossible for the axis of the eyeball to be shortened, but no doubt to some extent he learned by observation to recognise the faded images they saw. When young men candidates for the army came to him who were on the border-line, and it was a question whether they would pass the examination, he advised them to read the printed letters at the distance from which they would have to read them, and try to learn what they looked like to them; and he knew of more than one instance in which such advice had been followed with satisfactory results to the candidate. He should be very glad if he had succeeded in calling public attention to a matter which seemed to him of very great importance.

THE CHAIRMAN, in proposing a vote of thanks to Mr. Brudenell Carter, said it had been suggested that the Education Department should issue a circular on this subject. That was the object with which the Committee had been appointed, and he hoped when the report was presented it would throw a little more light on the subject. The Department always took the greatest pains before approving the plans of a school to see that the light fell in the proper manner. Mr. Carter, the architect, did his work in the most careful manner, and he was one of the most distinguished architects in his profession in London, and one of the best experts in school planning and building in the country.

The vote of thanks was passed unanimously, and the meeting adjourned.

Miscellaneous.

THE TABLE-GRAPE INDUSTRY IN FRANCE.

It is estimated that there are nineteen million acres of land in the world under vineyards. Of this France claims nearly one-third; she had more than her share when the phylloxera appeared, but replanting is now making good the loss, as the cultivation of the grape, whether for table consumption or wine-making, is very remunerative, as evidenced by the abundance and contentment of the growers. Besides, the culture of grapes affords constant and agreeable employment nearly throughout the year. The history of the vine, M. A. de Candolle asserts, is traced to the Bronze Age, as seeds have been found in the lake dwellings of Castione, in Italy, and some of the vine have been discovered in the soft subsoil at Montpellier, which coincides with the pre-historic period of our globe. What about the origin of the juice—of wine itself? Pictet

attributes it to the Semites and Aryans, and as these peoples migrated, they made known the process in the countries where they settled down, notably in Egypt, India, and Europe. Thus the vine and wine possess very ancient title-deeds.

In general, table grapes in France are grown in the open air, and by ingenious processes of conservation can be kept fresh up to June. Of course, there are hot-house grapes grown, and of late the artificial culture under glass is spreading in Northern France, as at Roubaix, Lille, &c.; where coal is relatively cheap, to dispute the foreign market with Belgian forced productions. These vinery grapes can never have any important sale in France; their price, 2s. to 3s. per lb., being only for persons with fat purses, and the owners of the latter being mostly *gourmets*, prefer the superior delicacy, flavour, and "bouquet" of the natural well-preserved Chasselas grapes. From the closing days of June till the middle of July, France has no open-air grown grapes; but then she has an ample supply of small fruits. Algeria sends the first consignments of fresh grapes to the Paris central markets; they have not the fineness and delicacy of the grapes of continental France, but they are rapidly becoming ameliorated by greater care in cultivation. Next to arrive are the grapes from Vaucluse, the Eastern Pyrenees, Hérault, and, in due course, the pleasant-eating Chasselas of Montauban and Toulouse. The Chasselas grapes have a thick skin, crisp pulp, sugary melting like a bonbon, and of delicious flavour. It is not a wine grape, because it does not yield much juice, and does not possess good keeping qualities; but it is a sure-cropping, profitable, table grape, that thrives on strong lands, and in a humid climate. The several varieties of Chasselas are not distinctly marked, and their differences are due more to soil and culture than to other causes. The Chasselas of Fontainebleau may be regarded as the parent of that celebrated variety, now so widely spread, because plants are raised in nurseries for sale.

Originally it came from the village of Chasselas, near Macon, and was planted in the royal park of Fontainebleau during the reign of Henri IV. or Louis XIII. It was shoots of this royal vine that Marmes, in 1730, planted, and made famous, at Thomery, a picturesque village, three miles from Fontainebleau, and sheltered on the north and west by the wood-clad hills.

In autumn, no more beautiful walk exists than to descend from the forest-heights of Fontainebleau into the lowlands, for miles around the country only series of walls covered with vines, espaliers, and *contre-espaliers*, are to be seen. This is the head-centre of the culture of the Thomery table-grapes, that only became a world-celebrated industry since 1840. Although a few cultivators raise grapes under glass, the normal culture is carried on in the open air. Perhaps the secret of the monopoly resides in the conservation of the fruit—as fresh and velvety as when first gathered on the vine—till May or June,

when they sell at from 5s. to 6s. per pound. The walls in the gardens are 33 feet apart, and 11 feet high; supports are fixed to allow of a sloping shelter of straw, wood, tarpaulin, or, better still, glass, to protect the vine-espaliers from injury by frost and rain. In the spaces between the walls are the *contre-espaliers* with galvanised wire for the branches, the latter equally protected from the severity of the weather by hoods of straw matting. All the vine branches are, as a rule, trained mostly horizontally and vertically. Following the mode of pruning adopted, the vines are planted 16 to 30 inches apart, and only one bunch of grapes per bearing branch is desired. The Thomery grapes owe their famous reputation to the *cisellement*, or thinning and *effeuillage*, or removal of foliage practised. When the grapes are about the size of a pea the bunches are examined, and every berry tending to obstruct the development of its neighbour, or presenting the appearance of an abortion, is carefully removed by a sharp and fine-pointed pair of scissors. That operation is called *cisellement*.

The removal of the leaves, when they interfere with the development of the bunch, is *effeuillage*; the second removal of the leaf will not take place till the fruit be matured, and is intended to expose the berries to the sun, in order to acquire the golden hue so much desired by *connoisseurs*.

In consequence of the extension of hot-house raising of grapes in the North of France, the large "Frankenthal" violet-black grape is not so much cultivated at Thomery. Experiments continue to be successfully made with hybridisation, and some other practices, to obtain a golden Chasselas with berries as large as the Frankenthal. The secondary quality of grapes grown at Thomery, those raised on the *contre-espaliers*, the insufficiently, or too-ripe, or the meagre-looking bunches, are packed in special small baskets, and sent to the Paris central markets, where they nevertheless obtain a top price. But the best grapes, that is to say, all the prime crop, and those destined to be conserved till the spring, are cut with a pair of scissors or a pruning-knife, and the bunches handled with care, so as to retain their bloom. These bunches are left uncut as long as sunny days will permit, thus allowing much of the water in the berries to evaporate, and in that way augment the quantity of sugar retained in the berries, of which as much as 30 per cent. has been found.

The Romans, in order to preserve grapes from one year to another, inserted a part of the branch with the bunch attached in a glass globe, and covered the mouth with pitch. At Thomery growers have special halls or rooms maintained at a temperature of 30° to 42° Fahr., where, on racks, wide-mouthed bottles filled with water are ranged, slanting-wise, and into which the piece of the branch, nearly 3 inches long, that has the bunch attached is inserted, and to be kept constantly wet. This will ensure the duration

of the plumpness and the original freshness of the berries. In the bottom of the bottles should be placed a few pieces of charcoal to prevent the fermentation of the water. The grapes to be thus preserved should always be cut during dry weather, and 3 inches of the branch attached to the bunch. The storage-room ought to have its openings facing north, and to be maintained hermetically closed to guard against atmospheric variations. It is essential to inspect the fruit frequently, and remove all that is affected with must; place in a corner some lump of quick-limestone or chloride of calcium to absorb the humidity, when the hygrometer exceeds 72 degrees, and if a musty smell exists, burn a few sulphur wicks. Grapes that are not expected to preserve their pristine greenness are stored by the small growers at Thomery in the central room on the first story of their dwelling-house; the bunches are placed on open-work shelves, so as not to touch, and are covered over with very dry rye straw or fern. The room must have facilities for ventilation, and maintain a usual uniform temperature and hygrometric condition of the atmosphere secured. It has been found that grapes obtained from vines not less than ten years old keep better than such as are produced by younger vines, and that the products of argillaceous soils preserve better than those from siliceous soils.

In Southern Russia fresh grapes are preserved in a well-closed cask with the finest cork dust, so that each berry be well embedded in the powder. In the South of France, where the grapes are excellent and abundant, all attempts made to preserve them throughout winter have failed—at Montpellier especially, owing to the sudden transitions of temperature.

The packing of the grapes for exportation is executed by women specially trained to do so. The small deal boxes are lined inside with the white paper, the border of the latter being of a lace pattern. The bunches of grapes are then laid, stalk up, so as not to touch each other, with paper separating them of an undulatory nature; a sheet of paper covers the lid, and the lid is closed down.

Hérault is the department which excels in ordinary vineyard table grapes, and these are forwarded to Paris, from August to October, in circular wicker baskets containing 25 lb. of fruit. It boasts to have Chasselas as good as those of Thomery, which is not quite exact. An acre produces two tons of grapes, which sell on the spot at a fraction less than one penny per lb. for transport to Paris, duties, storage, commission amount to 2d. per lb., so the retailer pays 1s. 10d. wholesale price, and sells at 5d. to 7d. per lb. The railway charge covers the return of the "empty" train. The "grape-trains" leave Montpellier at midnight, arriving at Paris in 23 hours; the grapes are delivered to the commission agent, and auctioned off six hours later.—Edward Connor in *Garden Chronicle*.

Correspondence.

STEAM-PRESSURE GAUGE.

Our attention having been called to the columns of an engineering mechanical paper, published in New York, under the style of *Locomotive Engineering*, p. 709, referring to the original inventor of the steam-pressure gauge, the writer of which report claims the honour of this invaluable invention being first brought into use by a Frenchman in 1850. As the merit of the invention of this important instrument belongs to an Englishman—the late Sydney Smith, of Nottingham, 1847 (three years before the French gauge)—we thought it of sufficient interest to send these facts to you, in confirmation of which we not only enclose you a copy of a letter from the inventor claiming the honour of the invention, but also one from the late George Stephenson, who was the first person to use it, and his observations thereon he voluntarily sent to the mechanical papers published in his day.

Our reason for sending you this information is for use in examining the papers left by the late Sydney Smith we have come across a letter written by one of the officers of the Society of Arts, dated October 2nd, 1847, and signed by Samuel Thos. Denport, which also is further evidence of the facts.

Mr. Sydney Smith has had no national recognition of the great benefit conferred upon mankind by this valuable invention, except the fortune he made out of it.

A full and accurate description of this first steam gauge appeared in the columns of the *Mechanical Engineer*, in the issues of July and August, 1897, and a leading article appeared in the *Railway Engineer* of July 17, 1897, on the same subject.

Knowing that many of your readers give special attention to such information as contained herein, we may deem it worthy for this letter to appear in the next issue of the *Journal*.

ISAAC SMITH

(Son of the late Sydney Smith).

Leeds Brass Works, Nottingham.

Feb. 21, 1898.

General Notes.

PORTRAITS OF MEMBERS.—Messrs. Maull & Fox for some time taken photographic portraits of members of the Society, and they have just presented the Society with a series of nearly two hundred life-sized portraits. Messrs. Maull & Fox have expressed their willingness to take photographs of members of the Society gratuitously, and to send a copy to the sitter.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock:—

MARCH 2.—“Kites: their Theory and Practice.” By Captain B. F. S. BADEN-POWELL. Professor W. GRVLLS ADAMS, F.R.S., will preside.

MARCH 9.—“Linde's Method of Producing Extreme Cold and Liquefying Air.” By Professor J. A. EWING, F.R.S. Professor JAMES DEWAR, LL.D., F.R.S., will preside.

MARCH 16.—“The Recent History of Paper-making.” By CLAYTON BEADLE.

MARCH 23.—“The Preparation of Meat Extracts.” By C. R. VALENTINE.

MARCH 30.—“Telegraphy Across Space.” By Professor SILVANUS P. THOMPSON, F.R.S. J. W. SWAN, F.R.S., will preside.

Dates to be hereafter announced:—

“Stage Mechanism.” By EDWIN O. SACHS.

“Water Gas and its Appliances.” By Professor VIVIAN LEWES.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock:—

MARCH 10.—“India and Sir Henry Maine.” By CHARLES LEWIS TUPPER, C.S.I. The Right Hon. Sir MOUNTSTUART ELPHINSTONE GRANT DUFF, G.C.S.I., F.R.S., will preside.

MARCH 31.—“The Earthquake in Assam.” By HENRY LUTTMAN-JOHNSON, I.C.S. The Right Hon. Sir HENRY FOWLER, G.C.S.I., M.P., will preside.

APRIL 21.—“The Rise, Progress, and Present Position of the Native Press of Western India.” By R. P. KARKARIA (of Bombay).

APRIL 28.—“India and Currency.” By Sir EDWARD SASSOON, Bart.

MAY 19.—“Chartered Companies and Colonisation.” By Sir ALFRED COMYNS LYALL, G.C.I.E., K.C.B., D.C.L. (Member of the Council of India).

The meeting of March 31 will be held at the Imperial Institute; those of March 10, April 21, April 28, and May 19 at the Society of Arts.

FOREIGN AND COLONIAL SECTION.

Tuesday Afternoons, at 4.30 o'clock:—

MARCH 15.—“The West Indies and Sugar Bounties.” By NEVILLE LUBBOCK.

Date to be hereafter announced:—

“The African: what he is, and what he is capable of becoming.” By the Rev. GODFREY DALE (Universities Mission to Central Africa).

APPLIED ART SECTION.

Tuesday Evenings, at Eight o'clock:—

MARCH 8.—“The Making of a Stained Glass Window.” By LEWIS FOREMAN DAY. WALTER CRANE will preside.

- MARCH 29.—"English Art in Illuminated MSS." By Sir EDWARD MAUNDE THOMPSON, K.C.B.
 APRIL 26.—"The Importance of Craftmanship." By Sir WILLIAM BLAKE RICHMOND, R.A., K.C.B.
 MAY 10.—"The Art of William Morris." By F. S. ELLIS.
 MAY 17.—"Practical Points in Italian Majolica Painting." By WILLIAM BURTON, F.C.S.

CANTOR LECTURES.

Monday Evenings, at Eight o'clock :—

HUGH STANNUS, "The Principles of Design in Form." Four Lectures.

LECTURE III. — FEBRUARY 28. — Repetition, Alternation, Axiality, &c.

LECTURE IV.—MARCH 7.—Simplicity, Reticence, Unity, &c.

PROF. W. NOEL HARTLEY, F.R.S., "The Thermo-Chemistry of the Bessemer Process." Three Lectures.

March 14, 21, 28.

DR. D. MORRIS, C.M.G., "India Rubber." Two Lectures.

April 18, 25.

PROF. CARUS WILSON, "Electric Traction." Four Lectures.

May 2, 9, 16, 23.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, FEB. 28 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Hugh Stannus, "The Principles of Design in Form." (Lecture III.)

Farmers' Club, Salisbury-square Hotel, Fleet-street, E.C., 4 p.m. Mr. T. Carrington Smith, "Proposed Legislation in restraint of the Adulteration of Dairy Products."

Scottish Society of Arts, Heriot-Watt College, Edinburgh, 8 p.m. Prof. Stanfield, "Experimental Investigation as applied in the teaching of Engineering."

Imperial Institute, South Kensington, 8½ p.m. Mr. F. Villiers, "The Re-Conquest of the Soudan."

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Dr. John Murray, "The Annual Range of Temperatures in the Surface Waters of the Ocean, and its bearing on Oceanographical Problems."

Actuaries, Staples-inn-hall, Holborn, 7 p.m.

Camera Club, Charing-cross-road, W.C., 8½ p.m. Messrs. T. C. and C. M. Hepworth, "A Corner of Normandy."

Medical, 11, Chandos-street, W., 8½ p.m.

London Institution, Finsbury-circus, E.C., 5 p.m. Rev. Canon Benham, "St. Paul's Cathedral."

TUESDAY, MARCH 1 ... Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. Ray Lankester, "The Simplest Living Thing." (Lecture VII.)

Medical and Chirurgical, 20, Hanover-square, W., 5 p.m. Annual Meeting.

Civil Engineers, 25, Great George-street, S.W.,

8 p.m. Discussion on papers by—1. Mr. L. B. Atkinson, "The Theory, Design, and Working of Alternate-Current Motors;" 2. H. F. Parshall, "Dublin Electric Tramway." Pathological, 20, Hanover-square, W., 8½ p.m. Roentgen Society, 11, Chandos-street, W., Messrs. J. H. Gardner and Wilson 1 "Photographic Action of Roentgen Rays." Various Vacua."

Zoological, 3, Hanover-square, W., 8½ p.m. J. Stanley Gardiner, "The Perforate collected by the author in the South Pacific." Prof. B. C. A. Windle and Mr. F. G. Pa "The Myology of the Terrestrial Carni (Part II.) 3. Mr. F. E. Beddard, "The Bra some other Points in the Anatomy of *Bassar*." Biblical Archaeology, 37, Great Russell-street, 8 p.m.

WEDNESDAY, MARCH 2 ... SOCIETY OF ARTS, John-Adelphi, W.C., 8 p.m. Captain B. F. S. B. Powell, "Kites: their Theory and Practice." Sanitary Institute, 74A, Margaret-street, W., Dr. C. Childs, "Water-borne Typhoid." Archaeological Association, 32, Sackville-street, 8 p.m.

Obstetrical, 20, Hanover-square, W., 8 p.m.

THURSDAY, MARCH 3 ... Royal, Burlington-house, W., 4 Antiquaries, Burlington-house, W., 8½ p.m. Linnean, Burlington-house, W., 8 p.m. 1. J. Cole, "The Sense Organs of the Lateral certain Fishes." 2. Mr. G. C. Druce, "The ence of *Carex helvola*, in Britain." 3. R. Pickard-Cambridge, "Arctic Spiders from Josef Land."

Chemical, Burlington-house, W., 8 p.m. Messrs. John Wade and Laurence C. Pa "Note on the Preparation of Dry Hyd Cyanide, and Carbon Monoxide." 2. Dr. Collie and Mr. T. Tickle, "Production of Nitro and Amido-oxylutidines." 3. Dr. Collie and Miss L. Hall, "Production of Nitro- and Amido-oxylutidines." (Part II.) Dr. E. Divers, "The Interaction of Magn and Solution of Copper Sulphate."

Society for the Encouragement of Fine Art Conduit-street, W., 8 p.m. Mr. Law "Primitive Ireland."

Sanitary Institute, 74A, Margaret-street, W., Mr. A. Wynter Blyth, "Sanitary Laws Regulations governing the Metropolis."

Royal Institution, Albemarle-street, W., 3 Prof. J. A. Fleming, "Recent Research Magnetism and Diamagnetism." (Lecture I.)

United Service Institution, Whitehall, S.W., 3 Major A. W. A. Pollock, "The Battle Train Infantry."

Camera Club, Charing-cross-road, W.C., 8½ Mr. Cyril Davenport, "Mediaeval and Embro Bookbindings."

FRIDAY, MARCH 4 ... Royal Institution, Albemarle-street, 8 p.m. Weekly Meeting. 9 p.m. Prof. T. E. Th "Some Recent Results of Physics—Chemica quiry."

Geologists' Association, University College, 8 p.m.

Junior Engineers, Westminster Palace Hotel, 8 p.m. Mr. A. H. Stanley, "An Outline of P law and Practice."

Philological, University College, W.C., 8 p.m. Quekett Microscopical Club, 20, Hanover-s W.C., 8 p.m.

SATURDAY, MARCH 5 ... Royal Institution, Albemarle- W., 3 p.m. Prof. Walter Raleigh, "E Letter Writers." (Lecture I.)

Journal of the Society of Arts.

No. 2,363. VOL. XLVI.

FRIDAY, MARCH 4, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.

ALBERT MEDAL.

The Council of the Society attended at Marlborough-house on Saturday, the 26th inst., when His Royal Highness the Prince of Wales, K.G., President of the Society, presented the Albert Medal to George James Monks, F.R.S., "for the services he has rendered to the United Kingdom by affording engineers engaged in the water supply and the sewage of towns a trustworthy basis for their work, by establishing and carrying on during nearly forty years systematic observations (now at over 3,000 stations) of the rainfall of the British Isles, and by recording, tabulating, and graphically indicating the results of these observations in the annual volumes published by himself."

The members of the Council present were:—Major-Gen. Sir Owen Tudor Burne, G.C.I.E., C.S.I. (chairman), Sir Frederick Abel, Bart., K.C.B., F.R.S., Sir George Birdwood, C.I.E., C.S.I., Sir Edward Birkbeck, Bart., Frederick Bramwell, Bart., F.R.S., Michael Reiche, Hon. Sir Charles W. Fremantle, C.B., Sir Douglas Galton, K.C.B., F.R.S., Graham Harris, Sir Owen Roberts, D.C.L., W. C. Roberts-Austen, C.B., F.R.S., Alexander Siemens, and William Luscombe, with Sir Henry Trueman Wood, Secretary, and Henry B. Wheatley, assistant-secretary.

CANTOR LECTURES.

On Monday evening, 28th ult., Mr. HUGH LUNNUS, F.R.I.B.A., delivered the third lecture of his course on "The Principles of Design in Form."

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.

APPLIED ART SECTION.

Tuesday, February 22, 1898; Sir GEORGE BIRDWOOD, K.C.I.E., C.S.I., in the chair.

The CHAIRMAN said Mr. Cyril Davenport, of the British Museum, was known to all interested in the subject of the lecture of the evening, as the author of a beautiful work on the insignia of the British Monarchy, entitled *The English Regalia*, published by Messrs. Kegan Paul and Co. in 1897. He was better known to the members of the Applied Art Section of the Society of Arts as a great authority on bookbinding, and only the previous evening he had read a charming paper before the Bibliographical Society on "Embroidered Books." He was also known to his personal friends as a practical enameller of great taste and skill and a most accomplished photographer. Mr. Cyril Davenport therefore needed no more than a formal introduction to his present audience, and he (the Chairman) would at once call upon him to read his paper.

The paper read was—

THE ENGLISH REGALIA.

By CYRIL DAVENPORT.

On the 9th August, 1649, under the Commonwealth, the ancient regalia of England at the Tower were totally broken up, but, fortunately, one or two pieces of the old Royal treasure connected with the coronation were then at Westminster Abbey, and they escaped. The most important of these were the golden ampulla, for holding the consecrated cream, the ancient coronation spoon, and the coronation stone of the Scottish kings, which was brought to England by Edward I. The ampulla and spoon are now at the Tower, and the stone is still at Westminster Abbey. On the restoration of Charles II., a committee was formed to direct the remaking of the regalia, which was done, after the old fashion, in 1662, by the Royal goldsmith, Sir Robert Vyner, who was afterwards Lord Mayor of London, and an intimate friend of the king. Many of the pieces now in the Tower were made, in the first instance, by Sir Robert Vyner, although the majority of them have been altered since his time. The insignia have also been considerably added to by James II., who caused new crowns, circlets, and sceptres to be made for himself and his queen, Mary of Modena; and further alterations and additions

were made for the joint sovereigns, William and Mary. In every case, orbs, sceptres, or crowns, a close adherence to old patterns has in general design been carefully preserved. The crown known as St. Edward's is the actual official crown of England, and even if it is not actually worn, it is always present at the coronation.

Besides this official crown, all our later sovereigns have possessed a state crown of a more ornamental kind, and these state crowns, as far as I can judge, have been largely altered for successive sovereigns. Formerly, kings wore their crowns in battle. Henry V. wore his at Agincourt—indeed, it is said to have saved his life from the Duc d'Alençon—and when Richard III. was killed at Bosworth Field, in 1485, his crown was hidden by a soldier in a hawthorn bush, who carried it to Lord Stanley. He put it on the head of the Earl of Richmond, and saluted him by the title of Henry VII. In memory of this, the king used as one of his badges a hawthorn bush with a crown in it, and there is a loyal old saying, "Cleave to the crown though it hang on a bush." The coronation ceremonies themselves were very elaborate, and although they are simplified now, in many ways the ancient order, in its material points, is still retained. The ceremonies that were used at the coronation of Richard II. are most clearly laid down in a little vellum MS. of the fourteenth century, now preserved at Westminster, and known as the "*Liber Regalis*." The order is, generally, as follows:—

1. The anointing.
2. The investment with the *Colobium Sindonis*, always a simple linen garment.
3. The dalmatic.
4. Shoes, buskins, and spurs.
5. Sword.
6. The stole, or armilla.
7. The Imperial mantle.
8. The crown.
9. The ring.
10. The sceptres.

It will be seen that there are insignia of two kinds in this list, those of a priest or bishop, and those of a soldier. The "*Colobium Sindonis*" may be considered an equivalent to the alb or rochet. The dalmatic, the stole, and the ring are all episcopal, and the Imperial mantle is analogous to the cope; the sceptre corresponds to the crosier, and the crown to the mitre. The purely military elements are the sword and spurs

From the time of Edward the Confessor until the reign of Henry VIII., the regalia were usually kept in the treasury at Westminster Abbey, by authority of their foundation charter; but the sovereigns had the privilege of taking them about with them whenever they wished to do so. The coronation vestments of Charles II. and James II. have been fortunately described and figured by Sir Edward Walker and Francis Sandford, in their accounts of the coronations of these kings, and the vestments used by Queen Victoria follow them closely in general design. These are now kept in the Robes office at St. James Palace.

The orb with the cross is a very ancient Christian emblem. It was borrowed by our Saxon kings from the Roman emperors, and the variations in the form of the cross which have occurred since the time of Edward the Confessor, may be followed to some extent from coins, but chiefly from the great seals, a complete collection of which exists from the Confessor's time.

From Richard III. to Henry VII. the crosses are raised upon a tall stem, ornamented more or less elaborately. On the great seal of Henry VIII., however, the cross rests directly on the orb, and this is the form it has retained ever since.

The sceptre first shows on a penny of Æthelred II. It is a rod with three pearls at the top. On the pennies of Canute the pearls have turned into a trefoil, and Edward the Confessor, on some of his pennies, holds one with a cross at the top, while on his great seal he is shown bearing a sceptre with a dove at the top. These two forms the cross and the dove, exist at the present time, and they may indeed be considered direct survivals of the pattern adopted by Edward the Confessor.

Taking coins again as an authority it appears that the early British kings wore ornamental wreaths or fillets, but on a penny of Æthelstan a helmet bearing a coronet with three pearls on raised stems shows very clearly. On a penny of Canute the three pearls have developed into three trefoils, and on some of the pennies of Edward the Confessor we come across an arched crown, with ornamental pearl tassels depending from each other side. The pearls gradually modified themselves into trefoils, which appear on the pennies of Edward I., and the arches show again distinctly on the third great seal of Edward IV. The centre trefoil, often larger than the others, is first shown with square ends, or, as we call it, a cross

patée, on the first seal for foreign affairs of Henry VI., and the actual form of the crown of Henry VIII. as shown on his coins and great seal, is in all particulars the same as the present crown, that is to say, a rim with crosses *patées* and *fleurs-de-lys* alternately springing from it, arched with a double arch, and surmounted by a mound and cross.

The ampulla or golden eagle, Fig. 1, is certainly, at all events in part, one of the oldest pieces of Royal treasure now remaining. With its pedestal, it measures about 9 ins. in height. It weighs about 10 ounces of solid gold, and is capable of containing 6 liquid ounces. The lid screws off its neck, and the oil pours out from the beak. It is said to be the original ampulla that was used at the coronation of Henry IV. (October 13th, 1399). I should think, however, that it has been considerably

FIG. 1.



THE GOLDEN AMPULLA.

been replaced upon and added to by Sir Robert Vyner. Both the pedestal and the wings appear to be comparatively new, and the body of the eagle has been completely worked over with a turning tool. The shape of the head and the beak appears to me such as may well have been designed at an early date, and this opinion is borne out by the fact that the screw on the neck is hand-made.

The coronation spoon, Fig. 2, about the age of which there is also considerable diversity of opinion, has, I think, also been added to by Sir Robert Vyner. It is figured by Henry Hallam in his book on the dresses and decorations of the Middle Ages, and he says:—"It is most probably been used in the coronation

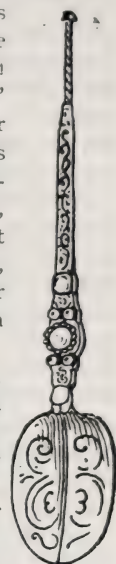
of our monarch since the 12th century . . . its style of ornamentation seems to prove that it was made at that period . . . there can, of course, be no doubt as to its antiquity." But there are other authorities who do not hold this opinion. The spoon is of silver gilt, and the handle itself is $7\frac{1}{2}$ inches in length. The bowl is $2\frac{1}{4}$ inches long, and has a curious rib down the centre, dividing it into two hollows, fitting the two fingers of the right hand. A considerable portion of the handle is ornamented with work known as "*champlevé*," a form of preparing metals for enamelling, and it has four pearls at its thickest portion. The decoration of this handle altogether, appears to me to be of an ancient character, and the bowl, I think, was most likely made by Sir Richard Vyner, copied in its main lines, however, from an older one.

Both the spoon and the ampulla, although distinctly Royal, have a sacredness attaching to them greater than that of any other pieces of the regalia, as they were actually used in the ceremony of anointing; and it may be partly to this idea of holiness that we owe their preservation.

The ancient coronation stone, which was brought from Scotland by Edward I. in 1296, has been kept ever since that time in Westminster Abbey, with the single exception of the time when Cromwell was installed Lord Protector, when it was taken to Westminster Hall. Our sovereigns have all been crowned upon it except Mary I. The stone itself is said to be that on which the patriarch Jacob slept on the plain of Luz. There is a long history about it in Holinshed's "*History of Scotland*." It seems to have been placed in the Abbey of Scone by King Kenneth in the 9th century. He found it near Dunstaffnage Castle, to the sandstone of which it has a near resemblance. King Kenneth had it enclosed in a wooden chair, of which the present one is a copy. The stone was supposed to groan whenever any of the monarchs of the Scythian race seated themselves upon it, and there was at one time a plate fixed in it on which was engraved a legend in Latin, which may be translated—

Except old saws do fail and wizards wits be blind,
The Scots in place must reign where they this stone do find.

FIG. 2.



THE CORONATION SPOON.

VESTMENTS.

The vestments worn by Queen Victoria are now kept in the Robes office at St. James's Palace, where they are under the charge of a regularly appointed official.

Colobium Sindonis.—The colobium sindonis is a garment of soft white linen edged with lace, and with a nine inch flounce also of lace. It is open at the sides and cut low at the bust, fastens on the left shoulder with three buttons, and on the right shoulder are three dummy buttons to match. A thick gold cord, corresponding to the girdle of the alb, was worn round the waist by the Queen at her coronation.

The Dalmatic.—The dalmatic is put on next to the colobium sindonis. It is a garment of cloth of gold without any fastening and has short, deep, pointed sleeves; it is edged all round with lace made of gold thread. It is lined throughout with rose-coloured silk. The cloth of gold has a delicately coloured design woven upon it. A scroll of palm-leaf pattern divides the surface into irregular compartments, filled alternately with rose, shamrock, and thistle, all in their proper colours.

The Stole.—Immediately over this Her Majesty wore the stole, which hung round the neck and depended on each side. In religious ceremonies of the present day the stole immediately succeeds the alb, but in the 11th and 12th centuries it was worn over the dalmatic, and this ancient custom is retained to the present day by deacons of the Greek church. The stole was sometimes worn crossed over the breast, an example of which can be seen on the golden bulla of the Emperor Frederick III. as worn in the 16th century. The stole itself is a band of cloth of gold, five feet two inches long and three inches wide. It is lined with rose silk, and the ornaments upon it are white eagles, roses, shamrocks, and thistles, each surmounted by a coronet, and woven in coloured silks and silver threads. At each of the ends is a red cross of St. George on a silver ground, finished off with a deep gold fringe. Although differing in detail, the ornaments upon this stole are, with the exception of the St. George's cross, the same as those on the stole worn by James II., but the crosses did exist on the stole worn by Charles II., the rest of the ornamentation being different, and of an arabesque character only.

The Imperial Mantle.—The royal mantles

worn by Charles II. and James II. were both ornamented with a palm-leaf scroll, arranged so as to leave oblong spaces. These spaces were filled alternately with roses and white eagles, the junction of the scrolls being marked by a *fleur-de-lys* and coronet, used alternately in rows.

The Imperial mantle of Queen Victoria follows the previous design very closely, but the palms give way to a closer-leaved pattern and besides the eagles and the roses, there are shamrocks and thistles, all woven in rich colouring. It is edged with a gold fringe, and lined with rose-coloured silk, and fastened with a rectangular gold morse or clasp, on which the figure of an eagle in relief, flanked by designs symbolical of the three kingdoms, is 65 inches in length, from the neck downwards, and 28 inches across the shoulders.

ORBS.

On the obverse of the great seal of Edward the Confessor, the orb is shown as a simple sphere, and he is holding it in his left hand; but on some of his coins it has a short cross upon it as well. The orb is not often shown on English coins, and when it is found it has always a short cross upon it. On one of

FIG. 3.



THE LARGER ORB.

the great seals of Henry I., he holds an orb with a cross and a dove, which combination seems to have been more favoured afterwards.

sceptres. On the first great seal of Richard I. is seen an orb with a cross upon a fillet stem, having leaves issuing therefrom, and on the first great seal of Henry III. this leaved stem shows in its most ornamented form. From this time until the reign of Henry VII., the stems of the crosses surmounting the orb are more or less elongated, and after that the stem finally disappears. There are two orbs now in the Tower; the older and larger one was made by Sir Robert Vyner for Charles II., Fig. 3, and it is figured in Sir Edward Walker's account of his coronation. It is a sphere of gold six inches in diameter, and has a fillet round the centre surmounted by an arch, each edged with pearls. These bands are ornamented at intervals with clusters of jewels, surrounded by diamonds, on filagree work in gold, ornamented with white and red enamels. At the top is a fine amethyst cut in facets, one and a half inches high, in shape two truncated cones ended at their bases. On this stands a beautiful cross *patée*, in the centre of which on the side is an emerald, and on the other a sapphire. The outlines of the cross, and the faces on the arms themselves, are closely set with rose-cut diamonds; in each of the four inner corners is a large pearl, and there is also a large pearl at the end of each of the three upper arms of the cross, the foot resting on a collar of diamonds.

The smaller orb was made for Queen Mary II., as she was, as well as her husband, an independent sovereign, and on the great seal of William and Mary they are shown with each hand each on the same orb, conveying the same idea of an equal authority. This orb is quite so large as the other, and the ornamentation upon it is simpler. It has a fillet round the centre, with an arch above it, outlined with large pearls, each fillet ornamented with cut jewels, emeralds, sapphires, and rubies, simply set. The small cross at the top is ornamented with coloured jewels and diamonds all simply set and different on each side.

SCEPTRES.

On some of the coins of Æthelred II. he is shown bearing a sceptre, and on the reverse of the great seal of Edward the Confessor is shown a sceptre with a dove, and on one of his pennies a cross. These are the two chief forms of sceptre which have been used ever since they still exist. The royal sceptre with the dove is two feet nine and a quarter inches in length, and the upper portion of it is wreathed

or twisted (Fig. 4). Most of it was made by

FIG. 4.



HEAD OF THE
ROYAL SCEPTRE
WITH THE CROSS.

by Sir Robert Vyner, but from the drawing of it which appears in Stanford's account of the coronation of James II., the part immediately below the large amethyst has been made since. This part is now an elaborate piece of workmanship, consisting of four jewelled arches resting on a jewelled rim. Between each of the arches is a jewelled rose, from which spring enamelled scrolls, white and black. On this substructure rests a large amethyst globe, faceted, and held in position by jewelled projections. It has a jewelled fillet and arch like that on the orbs, and the cross *patée* at the top is very thickly set with diamonds. The bands dividing the sceptre into three divisions are of blue and white enamel set with diamonds, and the foot is richly ornamented with a filagree pattern in open work of gold, enamelled in white and colours, and richly set with coloured jewels and diamonds.

The Queen's sceptre with the cross was made for Queen Mary of Modena, the wife of James II., but has been to some extent altered. It is all of gold and ornamented with diamonds only. The cross at the top has large diamonds cut to the shape of its arms and centre, and rests upon a globe with fillet and arch like the orb. Below this is a double *fleur-de-lys* with three leaves bending upwards and three bending downwards, each thickly encrusted with diamonds, some of them of large size. It is two feet ten inches in length.

The sceptre with the dove is a rod of gold three feet seven inches in length. At the top is a dove enamelled in white, with outspread wings, standing upon a cross. This rests upon a sphere with fillet and arch like that on the orb, thickly set with diamonds. The rest of the sceptre has, at intervals, richly jewelled collars with open work in gold, ornamented with white and coloured enamels. The Queen's sceptre with the dove is a little smaller than the King's, and it is richer in colour. The fillet and arch on the sphere at the top are set with coloured gems and diamonds, with leaves

of enamel, and the divisions between the parts of the sceptre are enamelled in dark blue and white enamels set with diamonds, and near to the foot is a graceful spray in open work of gold, ornamented in dark blue and white enamels, and richly set with coloured jewels.

CROWNS.

St. Edward's crown was made by Sir Robert Vyner in 1662, and is of great size (Fig. 5). The rim is edged with rows of large pearls, and on it are clusters of coloured jewels surrounded by diamonds and set on enamels of white and red, resembling very much those upon the larger rob. From this rim rise alternately four crosses *patées* and four *fleurs-de-lys*, ornamented with coloured gems and diamonds, set in white and red enamel filagree work. From each of the crosses *patées* rises an arch of gold, edged with large pearls, ornamented with gem clusters on enamel, and dipping deeply towards the centre. In the centre is a sphere of gold with fillet and arch like the orbs, jewelled with coloured stones, diamonds,



FIG. 5.—ST. EDWARD'S CROWN.

and pearls. Above this a cross *patée* widely set with diamonds and coloured jewels with a large spherical pearl at the top, and two large drop-shaped pearls at the end of each side arm, depending from small gold brackets. This is the official crown of England, and with it is the cap of crimson velvet, turned up with miniver, with which it is worn.

Queen Victoria's imperial state crown, Fig. 6, contains some of the historic jewels of England. It was made by Rundell and Bridge, in 1838, upon which occasion several new gems were

added to the old ones. It weighs something over 39 ounces, and the setting is of silver. The rim is open work, and in the front is the large sapphire which was bequeathed George III. by Cardinal York.* Sapphires a

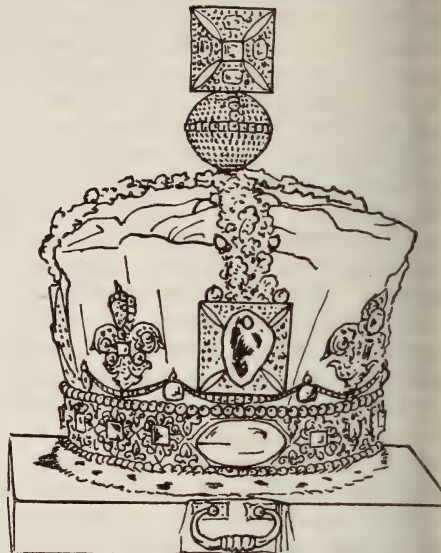


FIG. 6.—QUEEN VICTORIA'S CROWN ON ITS TRAVELLING STAND.

* In the *Journal of the Society of Arts* for Oct. 15, 1897, there is a figure and description of "The English State Crown," by Professor Tennant, F.G.S. He says that on the front of the crown is a large sapphire (partly drilled) purchased for the crown by his Majesty King George the Fourth." As this statement does not coincide with what I have said about this particular gem, I have been asked for further authority on the point. In the back of the setting of the State crown of Charles I. (now belonging to Lord Amherst of Hackney) is a perfectly fitting the large sapphire, and it doubtless occupied this place, and is referred to by Miss Ellis Cornelia Knight, lady companion to the Princess Charlotte of Wales, who in her "Autobiography," speaking of the Prince Regent (in 1813) says (p. 227) that on one occasion "He was in good humor, and had given to the Princess Charlotte [his daughter] the centre sapphire of Charles's crown, which he had received [for his father] with the papers of the Stuart family from Rome."

Also in the "Greville Memoirs," vol. 1, p. 46, there is a further mention of this jewel, i.e.:—"June 27, 1821.—The King [George IV.] dined at Devonshire House last evening. Lady Conyngham had on her head a sapphire which belonged to the Stuarts, and was given by Cardinal York to the King [George II.]. He gave it to the Princess Charlotte [as mentioned by Miss Knight], and when she died he desired to have it back, Leopold being informed it was a Crown jewel. The Crown jewel sparkled in the headdress of the Marchioness [Conyngham] at the ball."

It further appears that certain remonstrances about the stone were addressed to George IV., resulting in its retention by Lady Conyngham.

There seems to me little doubt that this sapphire is the Stuart jewel mentioned in both these extracts, and that Professor Tennant, in stating that it was purchased for the Crown by George IV., made a slight error as to the mode of its acquisition.—[C.D.]

emeralds alternately, in richly designed diamond settings, fill the remainder of the rim. Above the rim are eight sapphires, on which hang festoons of diamonds. These festoons support alternately crosses *patées* and ornamental *fleur-de-lys*, closely set with diamonds, a coloured stone being in the centre of each. The cross *patée* in the front of the crown has in its centre the great spinel ruby which belonged to the Black Prince in 1367, and was worn by Henry V. at Agincourt, in 1415. This ruby is pierced, and has a small ruby set in gold at the top of the piercing. From each of the crosses *patées* rises an ornamental arch of oak leaves and acorns, the acorns themselves being formed of oval pearls, the leaves and acorn cups being thickly set with diamonds. At each of the four corners of the intersection of the two arches hangs a large oval pearl. At the top is a sphere of open work, thickly set with small diamonds, with fillet and arch of large diamonds and above it a cross *patée* of open work, thickly set with small diamonds, a large diamond being in the centre of each arm. In the centre of this cross *patée* is a magnificent sapphire, said to have been worn in a ring by Edward the Confessor, and buried with him at Westminster.

This crown, besides the large ruby and sapphire, has 4 rubies, 11 emeralds, 16 sapphires, 277 pearls, and 2,783 diamonds.

The large ruby is said to be worth £100,000. A little box is provided for this crown whenever it takes a journey, the inside being lined with white velvet, with a sliding drawer and a boss on which the crown fits to prevent it from slipping. With this crown is worn a crimson velvet cap turned up with miniver, which is kept with it.

Besides the pieces of the regalia mentioned above, there are at the Tower the crown of Queen Mary of Modena, the circlet of the same queen, and the coronet of the Prince of Wales.

Among the minor treasures kept at the same place are also the golden bracelets, richly enamelled with the emblems of the three kingdoms, the golden spurs, the swords of State, mercy and justice, and the ivory rod of Queen Mary of Modena. Also the original setting of the Koh-i-noor, with a model of the stone itself as it was cut when it first came to England, is now kept there by special permission.

With regard to the art of the goldsmith, jeweller, and gem-setter, as seen on the regalia, we must all regret most deeply the

great loss occasioned on the destruction of the ancient pieces under the Commonwealth. There are many lists, some in Rymer's "Foedera," giving detail accounts of beautiful pieces of goldsmith's work—all gone; and even in the lists of pieces actually destroyed, mention is made of King Alfred's crown of gold wire work, set with slight stones, and valued then at £248 10s., doubtless of fine workmanship, and Queen Edith's crown, enriched with gems.

There is, however, one point to which I would draw attention, and it is that many of the existing jewels are set with enamels on gold open work, a style of much antiquity and beauty, and although when compared with the finest specimens of such work they lose somewhat, it must not be forgotten that they cover large spaces. Work of this kind is well seen on the handles of some of the sceptres, one of which I showed on the screen. These enamelled and jewelled scrolls are most likely Sir Robert Vyner's work, but have undoubtedly been repaired since his time. Both on the rim of St. Edward's crown and on the larger orb the jewel clusters are set on enamel sprays. The *champlevé* enamels on the bracelets are also good work, but they are not now quite as they left Sir Robert Vyner's hands. They have been subsequently imitated on the bosses on Queen Mary of Modena's ivory rod. Queen Victoria's imperial crown is so closely set with diamonds, generally rose cut, that it appears in fact a mass of brilliant colours. Such setting as there is shows very slightly, and is of silver, the pearls being held with gold wire. The rim, however, has a characteristic of some artistic value, the jewel clusters not being set in a solid metal ground, but arranged in open work, so that the crimson of the velvet cap shows through and accentuates the design.

Considered from the point of view of the diamond cutter, it may be granted that this crown is the perfection of design; but from the art jewellers' standpoint it is, of course, a question whether such undivided honour should be paid to faceted diamonds at all; and there is little doubt that, as the art of the diamond cutter has progressed—in fact, has almost reached perfection—so the art of the setter has declined and faded away to—not quite a shadow—but certainly a very small substance indeed.

There are ancient and magnificent crowns in Hungary, Germany, and Russia, set largely with fine enamels and jewels cut

en cabochon; but each of these crowns is made on a different design, one which has been invented for it. Our English design of cross *pateé* and *fleur-de-lys* alternately rising from a rim alone is a survival and development of an older form.

NOTE.—Mr. Davenport showed coloured slides of all the pieces of the regalia mentioned above, as well as several of the great seals, and peers in their coronation robes, showing how the various objects were carried in the coronation procession of George IV.

DISCUSSION.

The CHAIRMAN said they had to congratulate themselves on the paper they had heard read that evening, and on behalf of all present he begged to most cordially thank Mr. Cyril Davenport for it. It was a great privilege, which everyone in the room, he was sure, had gratefully appreciated, to listen to Mr. Cyril Davenport while he so clearly and pleasantly, and, by the aid of his beautiful photographs, so vividly brought the various objects of their regalia in succession before them. He doubted if any one in that room had ever before so distinctly seen, and so fully understood, these ensigns and emblems of their world-wide, imperial monarchy; for, owing to the misty history of many of them and the obscurity in which they were kept, and the intricacy of their obscurity, some being "on view" (on the *lucus a non lucendo* principle) in the Tower, and some locked up in St. James's Palace, and one lying in lumber in Westminster Abbey, owing to all this confusion, there is great popular ignorance of these actual objects,—the vestments and the ring, the coronation stone, the balm, the crown, the sceptre, and the ball—notwithstanding the deep popular interest in them as national heirlooms, if not as sacred symbols, dating from the profoundest antiquity, of "such divinity as doth hedge a king." He would particularly draw attention to the delicacy and vividness of Mr. Cyril Davenport's coloured lantern slides. His colouring of the vestments, for its accuracy and artistic quality, was a marvel of illustrative skill, and did Mr. Cyril Davenport the highest credit. He had no criticisms to offer on the paper, but for the sake of promoting a discussion on it he suggested that they might consider its subject under three heads, the art of the British Regalia, the history of the British Regalia, and the history of regalia generally. On the first head he would ask Mr. Stannus to speak, and himself would only draw attention to two facts; (1) that the most artistic objects shown them belonged to the Scotch regalia, and were of Italian design and workmanship, another illustration of the obli-

tion of English art to foreign influences, and of the ignorant arrogance of the popular outcry of our day against foreign competition in trade and commerce; and (2) that the older English regalia are the better they are, and the later in date the worse they are in art, until you come to the worst of them all, the Imperial Crown of the reigning sovereign. There was no "style" in its form; and there were two errors in its execution, one of which was fatal. The stronger part of a crown should be the circlet, its essential part. But in the present Imperial Crown this was the weakest part of it, owing to the ignorant, inartistic manner in which the ornamentation of the circle with gems and precious stones had been executed. The other error was the excessive size of the characterless cross above the orb on top of the crown. The "Imperial Crown" on some of Henry VIII. coins ("Rose Crowns"), and on "florins" of the present reign, is perfect in design. With reference to the second head, he would only remark that, excepting the crown, all the British regalia seemed to be of Oriental origin. This was obvious in the case of the vestments and in regard to the "Colobium Sindonis," he would remind them that the ancient fabric *Sindon*, the *σινδών* of the Greeks, and *sadin* of the Old Testament (Judges xiv. 12 and 13, Proverbs xxxi. 24, and Isaiah iii. 23) was simply Sindian, i.e., Indian muslin. The spoon, in its form, might be traced through Italy and the drinking spoons of Persia, back to sacrificial and anointing spoons of the liturgy of the Hindus of India. It was, in actuality, probably the oldest of the English regalia. In idea, however, the "ampulla," or chrismatory, referred back to profounder, and indeed to an abysmal antiquity, when divinity was identified with virility, and every symbol of divinity was of phallic significance. But this belongs to the next head, and here he would only say that he did not think the form of the English coronation *ampulla* was intended to represent an eagle. The original symbol of the Holy Spirit was the dove; the dove associated with Astarte, an Aphrodite, and with the Virgin Mary,—

"the Dove so white so chaste

On the Blest Virgin's head, so chaste, so white,—"

and the tradition that the British "ampulla" was originally the gift of the Virgin Mary looked like a confirmation of this view. The "eagle" of the "ampulla" was possibly modelled by a cockney goldsmith—who he never seen either an eagle or a dove—from a plucked turkey,—the "Turkey-cock" having been introduced into this country from America so early as 1530. The doves on our regal sceptres are meant for doves in their actual modelling, but probably simply in the modeller's ignorance, for the symbol surmounting the sceptre of imperial sway was in ancient times the eagle. He had said enough, considering the lateness of the hour, on the third head under the second. He would only add that all the most mysterious "attributes" of royal and imperial, regarded as actual, or delegated, divine,—power

ere, in origin, symbols of virility, from the simple seal, to the zenanas and harems (seraglios) of oriental potentates. The seal has more than one origin, but the ancient pebble, or pebble-like seal, of which our modern Western seals are a survival, was originally simply a symbol of adolescence, as it still is among some tribes of savages, who mark the formal admission of a youth into the full membership of his tribe by presenting him with a stone engraved with the totem of the tribe. The same ritual was observed in the Mithraic and the early Christian mysteries, and is referred to in the Revelation of St. John the Divine, ii. 17: "To him that overcometh will I give . . . a white stone, and in the stone a new name written, which no man knoweth, saving he that receiveth it." The other gifts are, "The Tree of Life, which is in the midst of the Paradise of God," and the immortality of perpetual onship, and "power over the nations,"—quite a Hindu formula, and clearly indicating the seal as the symbol of fully instituted manhood and dignity, and power and sovereignty.

Mr. HUGH STANNUS said that when looking at the very interesting photographs which had been shown, his first thought was how very tawdry it all was, and what a pity it was that people could not show their distinction intellectually rather than by wearing crowns or coronets to indicate their eminence. But, of course, it was all part of the system of symbolism, there was a story which illustrated the belief of the vulgar that peers habitually wore their coronets, even though they did not sleep in them, in an American book. One of the Western States an old miner had a mine which he was hoping to sell to an English lord, and in expectation of a visit from the purchaser, he duly "salted" it; but when his visitor arrived, being simply a well-dressed, gentlemanly-looking old party, he was very rude to him, not thinking it possible he could be the peer he was expecting as he had no crown on. When we hear of the various crowns which formerly existed, but had now disappeared, it brought home to him a point which he thought of great importance, viz., the convertibility of gold. If these crowns had not been made of a precious metal which was readily convertible, they might have remained to the present day and would have been of inestimable value as specimens of the art of the time. But articles of gold were too precious to be preserved in times of upheaval, and were melted down and disposed of. He had intended to make some mark on the superiority of the Scotch regalia to the English, but had been anticipated by the Chairman. He would only say, with regard to the objects made for James V. of Scotland, whose daughter was married to the Dauphin of France, that it was a markable feature that in both the sceptre and sword the dolphin was used as the chief motive of the decoration. He would like to know if, in Mr. Ravenport's opinion, that was symbolical, or was it simply used by the artist as he might have used a

pomegranate or a ram's head, or any other detail, when he was hard up for an idea. We would be inclined to think that in this case the dolphin was used symbolically. With regard to the Chairman's destructive criticism of the Queen's crown, he entirely agreed that the crown ought to be solid, the cresting being cut out of the same piece of gold as the circlet. He hoped it would be a long time before a new crown was required; but when the day did come, he trusted the artists would have some part in the designing of it, so that its value might include some element of art and not depend entirely on the richness of the material. Even the stones and the crimson velvet were as raw in colour as possible, and unless blue and orange had been used, he could hardly conceive anything more crude. We could surely enamel now as well as ever, and he hoped there would be a little more scope for the art of the enameller as well as of the jewel-setter. He noticed that one of the crowns had been described as the "Imperial" Crown, but he had always understood that the Imperial Crown should have four intersecting arches making eight arms. In fact, the whole arrangement of crowns and coronets had been reduced to a system: thus, a baron's coronet has six pearls, a viscount's twelve, an earl's pearls and strawberry leaves, a marquess's strawberry leaves and low pearls, a duke's strawberry leaves only. Strawberry leaves and the cross *patée* belong to princes of the blood, while the Prince of Wales has the *fleur de lys* with the cross *patée* and one arch, and the Royal crown has two arches. If ever the monarchs of these realms should take upon themselves to be called Emperors, not only of India, but of Great Britain and Ireland, the crown should have four arches, which, he ventured to think, from an artistic point of view, would be a great improvement. In some of the crowns shown the arches were of a true arched shape; but in others the arch was considerably dipped in the centre. There was, perhaps, a certain advantage in the dip, in order to accommodate the orb, or mound, which, with the cross *patée*, would otherwise make the crown very tall; but looking at the old Persian crowns, which were three or four feet high, he would plead for retaining the true shape of the structural arch. The crown as used in official documents at South Kensington has the perfect arch, and it is much more pleasing in shape than the crown made for George IV. It also appears on the florins. With regard to the ridge in the spoon, he was inclined to think it was introduced for the sake of giving strength to the bowl rather than to accommodate the two fingers of the consecrating archbishop, because, in the act of blessing, the two fingers and thumb were used as emblematical of a trinity. With regard to the ampulla, or golden eagle, he ventured to doubt whether the body was really old, because there seemed a little too much anatomy in it. Independently of the mere surface chasing of the body with the feathers, the legs were articulated in an anatomical manner, whereas in old representations of

a dove, they were made of a straight conical shape, and they were just soldered on to the lower part of the abdomen. They were much indebted to Mr. Davenport for the admirable manner in which he had illustrated his subject. Most people had seen the actual regalia, but only in the midst of a crowd, and in a very dark room, where the details could only be seen very imperfectly, and he could only hope that Mr. Davenport's book, with its superb illustrations, would be available at many of the public libraries.

Mr. H. B. WHEATLEY said he agreed with the Chairman and Mr. Stannus that it was very difficult to see the different objects of the Regalia properly at the Tower, and he was glad to add his testimony to the beauty of these coloured slides. He thought perhaps the most interesting object was the ampulla, and that probably it was in part, at any rate, one of the oldest. Not only so, but holding the holy oil which was used at the coronation, it was supposed to confer on the kings of England and France the power of curing the king's evil by touch. In France it was called the holy ampulla (*la Sainte Ampulle*), and curiously enough, a celebrated historian being confused by this title supposed that *La Sainte Ampulle* was a female saint. They had heard a great deal of Sir Robert Vyner, the king's goldsmith; this was the Lord Mayor, of whom it was narrated that on one occasion at a City banquet, as Charles II. was going away, he laid hold of the king, saying, "Come and have another glass before you go." He had been looking into Pepys's Diary to see if he made any reference to the regalia, and he found that on April 23, 1668, he took some ladies to the Tower and showed them all there was to be seen, and amongst other things the crown and rich plate, which he described as "Noble, and I mightily pleased with it." Mr. Davenport told them that the crown which Thomas Blood stole on 9th May, 1671, was the one he had shown on the screen now belonging to Lord Amherst of Hackney; he had been under the impression that it was the St. Edward's crown which was made for Charles II. to replace one supposed to have belonged to Edward the Confessor. It was said that this monarch was the first who had the power of curing the king's evil, but he did not know that there was any record of his having exercised it, and it was not until some time after the Conquest that any English kings touched for the evil. He should like, in conclusion, to put in a plea on behalf of English art. No doubt the condemnation was quite justified with respect to later art, but the more it was looked into the more it would be found that in the middle ages England was at the head of the art world; this was so in bookbinding, in enamels, in illuminated MSS., and in many other branches of art.

Mr. BARCLAY suggested that it would be interesting if Mr. Davenport could give the exact size of the various crowns, as he had done with respect to some of the objects.

Mr. DAVENPORT, in reply, said he was very glad to find that Sir George Birdwood was of opinion that, at any rate, of the spoon was old, and that his name could be added to those of the other authorities who held that view. As to the eagle being corrupted dove, it was rather too long a question to go into, but he did not think it was a dove; for one reason, which Mr. Stannus had pointed out, that the legs were not those of a dove, the thighs being very large and strong. It was no doubt true that much of our art we owed to the East. He did not think the Queen had ever worn her crown since the coronation, and it was a curious thing that peers did not seem to know anything about their coronets and other insignia of rank. While preparing his book he happened to be staying for a short time with two peers, one a viscount and the other an earl, and asked to see their robes. Neither of them had the least idea how many pips he had on his coronet, nor that the little black spots on his mantle indicated their rank, but they told him that the older the robes were the better they liked them. He had special information enabling him to answer the question as to the dolphins being symbolical, but should think it highly probable. Enamels could be made well now as ever, but you would have to find the man to do it. Success in obtaining a translucent enamel depended enormously on the purity of the gold on which it was applied. Nowadays people often tried to make translucent enamels on inferior metals, but the result was never satisfactory. The Imperial crown, so-called, was merely a name, having been made long before the Queen was proclaimed Empress of India. He still thought the ridge in the spoon was introduced to fit the fingers, the bowl being so small that it did not require anything to strengthen it. The large sapphire was undoubtedly a Scotch one, but originally, no doubt it was Oriental, being pierced.

The CHAIRMAN then proposed a cordial vote of thanks to Mr. Davenport, which was carried unanimously.

TWELFTH ORDINARY MEETING

Wednesday, March 2, 1898; Prof. V. GRYLLE ADAMS, F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Clarke, Philip Hamilton, 223, The Grove, Hammondsmith, W.

Davenport, Cyril James, The British Museum, W.C.

Pitt, Walter, Grove-lodge, Lansdown, Bath.

Read, Harry V. Rudston, Hyde-park-court, S.W.

Whinfield, Edward Henry, M.A., St. Margaret's, Beulah-hill, Norwood, S.E.

The following candidates were balloted for and duly elected Members of the Society:—

tkinson, Alexander, Camp, *viâ* Jammu, Kashmir India.
urnell, Arthur Edward, 123, Harbut-road, New Wandsworth, S.W.

The paper read was—

KITES: THEIR THEORY AND PRACTICE.

BY CAPTAIN B. F. S. BADEN-POWELL,
Scots Guards.

The Kite, one of the oldest of inventions, familiar to everyone and to every nation under the sun, is nevertheless but little understood. It has always been the custom to look upon this contrivance as a toy and nothing else. Very seldom indeed, until the last few years, has it been put to any practical use. Yet it is full of promise, and those few who have made regular and careful experiments in this line have all been impressed with the satisfactory results obtained. A kite sailing in the wind gives a very considerable pull on its line, which pull can be converted into lifting power or tractive power. This appliance may then be used for lifting great weights, such as that of a man, high into the air, or it may be used for towing carts or boats. Kites can be made to ascend to very great heights, carrying up automatically registering meteorological instruments, or may carry a string to communicate with places a long distance off. Why then, it may be asked, are they not more often made use of? I believe the sole reason is that so few men have devoted any time to studying the theory of their actions, and that even the well-known rule-of-thumb patterns have departed from, innumerable difficulties crop up, and the apparatus, for some inexcusable reasons, becomes frequently unsatisfactory, so that a cursory investigation of the subject only opens up a vista of obstacles apparently almost impossible to surmount. But with a little practice and study the way becomes somewhat clearer, and, as we grope along, fresh discoveries are made which raise our hopes and show what great results we may possibly attain.

I.—PRACTICAL EXPERIENCES.

Having devoted a considerable time to researches in this line, and with a view of throwing some light on the intricacies and difficulties to be met with in kite-flying, I will briefly relate my own personal experiences on this subject. To begin with, I had one definite object in view. For some time I had been interested in and had practically worked

with captive balloons for military purposes, and finding the behaviour of them so erratic in strong winds, to say nothing of the difficulties of construction and inflation with gas, and of the cumbrousness of the necessary apparatus, I was looking about for some other means by which a man might be lifted to a height above the ground. Kites naturally soon suggested themselves, and on investigation I found that trials had actually been made on several occasions to lift a man by this means, but that the trials had invariably proved failures.

In 1887, I made several trials with small cambric kites. The largest of them was 10 ft. high, and had two cross-pieces about 4 ft. wide. This only lifted a weight of 2 lb, which was attached to the tail. Many varieties of kites were tried. Some were of the ordinary diamond pattern, some had a bowed top; one was circular. I even got a kite to fly which was absolutely frameless. However, I came to no very definite conclusions, my experiments were knocked off, and I had no opportunity of continuing them for five years.

In 1892, I made trials with a 20 sq. ft. kite, from which I obtained two most important results. The first was that I found it possible to do away with that appendage known as a "tail," which I had hitherto presumed to be indispensable, and the second result was that by attaching a bag to the string some distance from the kite, I found I could put weights into it until the kite was able to lift a weight of 6 lb. or more in a fairly strong, though not exceptional, breeze. This result, the lifting of 3 lb. per square foot of kite surface was most encouraging, and convinced me that, under such circumstances, I should be able to lift a man with a kite of 500 square feet. I, therefore, determined to go to a suitable place and carry out a regular series of experiments for a week or two. I thus learnt many lessons, one of the principal being to appreciate the fickleness and variability of the wind. A kite which flew perfectly one day would scarcely rise on another. It would be impossible to give anything like a detailed account of my numerous experiments. I tried a great variety in forms of kites and attachments of string. I have records of twenty-seven different days' experiments in that year, and many of them were devoted to very small details of construction. These experiments were continued the next year, but it really seems extraordinary how little actual progress resulted, so often did one particular

idea have to be tried again and again under all conditions, before any decided conclusion could be arrived at; and as often as not did I finally conclude that that whole series of experiments was absolutely negative. Yet, again and again I had such successful days of work that I was encouraged to continue. Here are some of the designs with which, together with many others, I experimented (see Fig. 1). They all have certain advantageous qualities, but each required endless alterations before really satisfactory results were obtained.

1. That a tail is an unnecessary appendage to a properly constructed kite.

2. That by means of two strings suitably attached a kite can be guided so as to fly with some 45° to each side of the wind course, and under favourable circumstances more.

3. That a kite which is perfectly flat, in very light weather will fly well, but that in strong winds it will be very unsteady.

4. That if it be given much of a "diedral angle, that is, if the sides of the kite are thrown back like a butterfly's wings, or if it presents

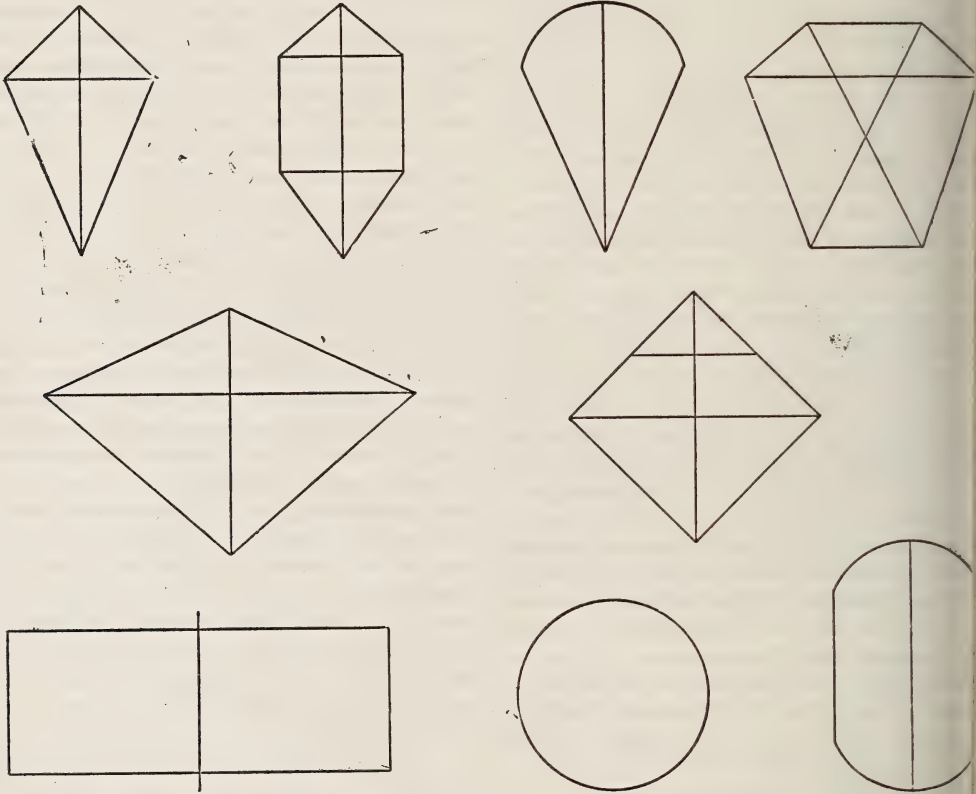


FIG. 1.—SHAPES OF EXPERIMENTAL KITES.

These experiments have continued off and on up to the present, but, as I have said, it would be impossible for me to detail them all, though carefully recorded, I having up to date records of close upon 200 different days' experiments. I will therefore endeavour to summarise the results which I obtained.

I soon found that the wind force is always so variable from one moment to another that to record its velocity during experiments was hopeless, even though that may seem a necessity in careful scientific experimenting. I proved:—

convex surface to the wind it will not rise to so great an elevation as if flat, but will be steadier in strong winds.

5. That a large kite flies more steadily than a small one.

6. That if the vertical section of a kite presents a concave curve from top to bottom (thus ) the kite will ascend to a certain height and then "top," that is, dive over forwards till it lies horizontally on the air, and will then sink to the ground. But that if the form of the kite is such that its section presents two or more curves (thus ) this tendency is prevented.

7. That the angle which the string takes with the horizon is variable, depending on the form of the kite and on the strength and direction of the wind (which sometimes has an upward trend). The most usual forms vary from 30° to 50° .

8. That the weight which a kite can lift will of course depend very greatly on the wind force, but a concave form of kite is more powerful than a convex one. In a light wind about $\cdot 1$ lb. per sq. ft. of kite may be counted on, in medium winds $\cdot 3$ lb., in strong $\cdot 5$ lb.

9. That if the weight to be lifted be affixed to the kite, or very close to it, it is very liable to upset the equilibrium of the kite and render it unsteady.

10. That "duplex" lines, that is two remaining lines fixed apart on the ground, and attached to two points, one on each side of the central axis of the kite, enable it to fly with great steadiness in all winds.

11. That in light winds the line may be attached higher up on the kite than in strong winds, and that this raising of the point of attachment causes the kite to rise easier, but to be more unsteady.

12. That a "regulator," or line attached to the lower part of a kite, the pulling of which alters the angle it presents to the wind, causes it to rise or fall as desired.

13. That the pull of the string of a kite may be taken roughly as—in light winds $\cdot 1$ lb. per sq. ft., in moderate $\cdot 7$ lb., in strong up to 2 lb. per sq. ft. of kite surface.

As for shapes, there are many kinds which fly well if properly adjusted. The following points have to be considered:—

1. *Lightness*, so as to ascend easily in light winds. For some purposes it may be desirable to construct special kites, but these very light ones should never be used in strong winds, else they might become strained or damaged. 2. *Stability* in strong winds, which quality may also necessitate heavy construction, rendering the kite useless in light airs. 3. *Portability*.—For most purposes, especially when large kites are desirable, it is necessary that they should be easily folded. 4. *Simplicity*.—The more complicated forms of kites are very liable to damage, and one little detail going wrong may upset the balance and the whole efficiency of the kite. 5. *Power* to lift or draw. Some forms of kite possessing these qualities may not have so much power as others. Thus a baggy concave kite is powerful, though perhaps unsteady. 6. *Good Rise*, that is to say power

of attaining a steep angle with its string. 7. *Strength*, both to withstand the pressure of wind and to stand knocking about while on the ground.

Though not absolutely necessary, a vertical backbone down the centre of the kite seems desirable. The crosspieces to hold out the material transversely may be in front of or behind the cover, but what is better still is to have them enclosed in seams in the material.

A difficult question to decide is that of flexibility or rigidity. If the framework of a kite be very flexible, it may in strong winds so bend when struck by a strong squall that it lessens the effective area, and thus automatically regulates the pull on the line. This characteristic would appear to be most desirable. I have arranged kites with springs, so as to fold back diedrally when struck by unduly strong puffs; but practically I must own that so far I have not succeeded in devising any very satisfactory arrangement. The same may be said as regards springs applied to the bridle so as to allow the kite to automatically present a different angle to the wind, according as it is strong or light. In practice a stiff, rigid kite is generally the most satisfactory, even though the pull on the line may in consequence be as variable as the changes of wind force.

What I have hitherto found to be the best form all round, is one nearly hexagonal in outline, stretched on a framework consisting of three poles of equal length, one forming an upright "backbone," the other two placed across it at right angles to form "crosspieces." This form of kite is very simple and portable, as, when the backbone is unshipped, the kite (with its bridle) can be rolled up on the crosspieces. When flying, all the central square forms a powerful concavity, or rather two concavities divided diedrally by the backbone to give steadiness, while the top triangle prevents all tendency to "top." This pattern, for distinction, I have designated "levitor." As regards size, I find the most convenient to be 12 feet high and 12 feet wide. This is about the largest size that can be handled easily. The poles are as long as can be conveniently transported in one piece. Such kites weigh complete from 5 lbs. to 7 lbs. according as they are intended for light winds or strong, and have an area of about 110 square feet. I have about fourteen such kites. My largest kite was 36 feet high, containing 500 square feet, but this, though I flew it on some twenty different occasions, I found to be rather unwieldy. I have one 24 feet high which is more

convenient. I am still not quite decided whether it is practically best to use one or two large kites, or a number of small ones, for lifting weights such as a man. Small kites are handier—they are lighter for a given area (since very large kites necessitate very large poles), and if one becomes damaged it is more easily replaced, and if an accident occurs to one kite while flying in mid-air, there is not necessarily a sudden collapse of the whole apparatus. On the other hand, big kites are simpler to make, and require but one adjustment. They seem to float more steadily in gusty winds (since they are acted on by a number of variable currents), there is less complication of strings, and they are probably more efficient. I have frequently tried an appendage like the rudder of a ship, which has a decidedly steadying effect.

There is one form of kite which calls for special comment. It is known as the "Hargrave" or "box" kite, having been invented by Mr. Hargrave in Australia. I have here a specimen which will more readily convey an idea of its peculiar construction than a long description. You see it is like two boxes with their lids and bottoms knocked out and connected a short distance apart. This kind of kite has found great favour in America, where it has been used for many purposes, including the high ascents for meteorological purposes at the Blue Hill Observatory.

My own experience with such kites is rather limited, but in practice I have found them possess very little advantage over other good forms, and I am unable to comprehend any very special theoretical advantage in them.

Such a form of kite is bound to be heavy, and I will endeavour to show later on the theoretical objections to a heavy kite. The average weight of those used at the Blue Hill Observatory is about 1 lb. per sq. ft. of sustaining surface. My "levitor" kites (which are of much larger size, and should therefore be heavier in proportion) average 0.5 lb. per sq. ft. That is just half the weight for a given area. It is almost bound to be more complicated and difficult to fold up. Being heavier, I have always found a Hargrave more difficult to get up in light winds. In very strong winds, though the Hargrave may perhaps be steadier than any other single line kite, there is no comparing it for steadiness with one on a system of duplex lines. Still, for certain purposes, such as attaining great elevations in strong winds, it may be useful.

As regards retaining lines, I have generally

used one of three systems: (1) the usual single line; (2) the "duplex," with the two lines fixed apart so that they join the kite at an angle of about 60° ; and (3) the "rein" or steering lines (for small kites) in which the duplex lines are held together in the hand, and used like reins for steering the kite.

The first system is employed if it is desired to get out a great length of line, or for towing and when steadiness is not a matter of importance; the second, when great steadiness is desired; and the third for steering kites.

In using several kites together, there are several different methods of attaching them best explained by diagrams.

a. The "duplex" applied to several kites (difficult to apply more than two or three kites).

b. "Parallel" system, each kite presenting the same angle as the one below it, and thus the whole system is under control.

c. Single line passing through the kites.

d. Single lines, each lower kite having "back bridle."

e. Independent kites "buoying" the line.

Each of these systems is applicable under certain circumstances, and a combination of one or more is often used.

I have here a specimen of a kite fully fitted by this system of running thimbles it can be used so as to fly independently on a single line, or duplex on two lines.

I also have a model to show what I believe is the best method of suspending the car to lift the man. In this he is perfectly steady. It cannot swing or rotate.

As regards materials, I have found that for the framework of all kites there is nothing like bamboo, though this material may be obtained in many different varieties, some not so suitable as others. I have tried various sorts of wood but have always been dissatisfied with it. It is generally either too heavy or too brittle. Male bamboo, though very strong, is too heavy or too flexible. The same in an increased degree may be said of steel tubing. The thinnest steel I could obtain is very much heavier than bamboo of somewhat the same diameter, even though it may be stronger. Kite of much less diameter it does not possess the requisite rigidity. It is of course also much more expensive.

The cover I have usually made of light cambric, which is very satisfactory, seldom tearing unless through catching in some tree &c. For very light kites I have tried silk, and also goldbeaters' skin. Paper is a wretched

material, even for the roughest models. It is so liable to get torn even before an experiment can be completed with it.

great advantages; but in practice—at all events for experimental work—its liability to kink, to get rusty, to attract lightning, and its

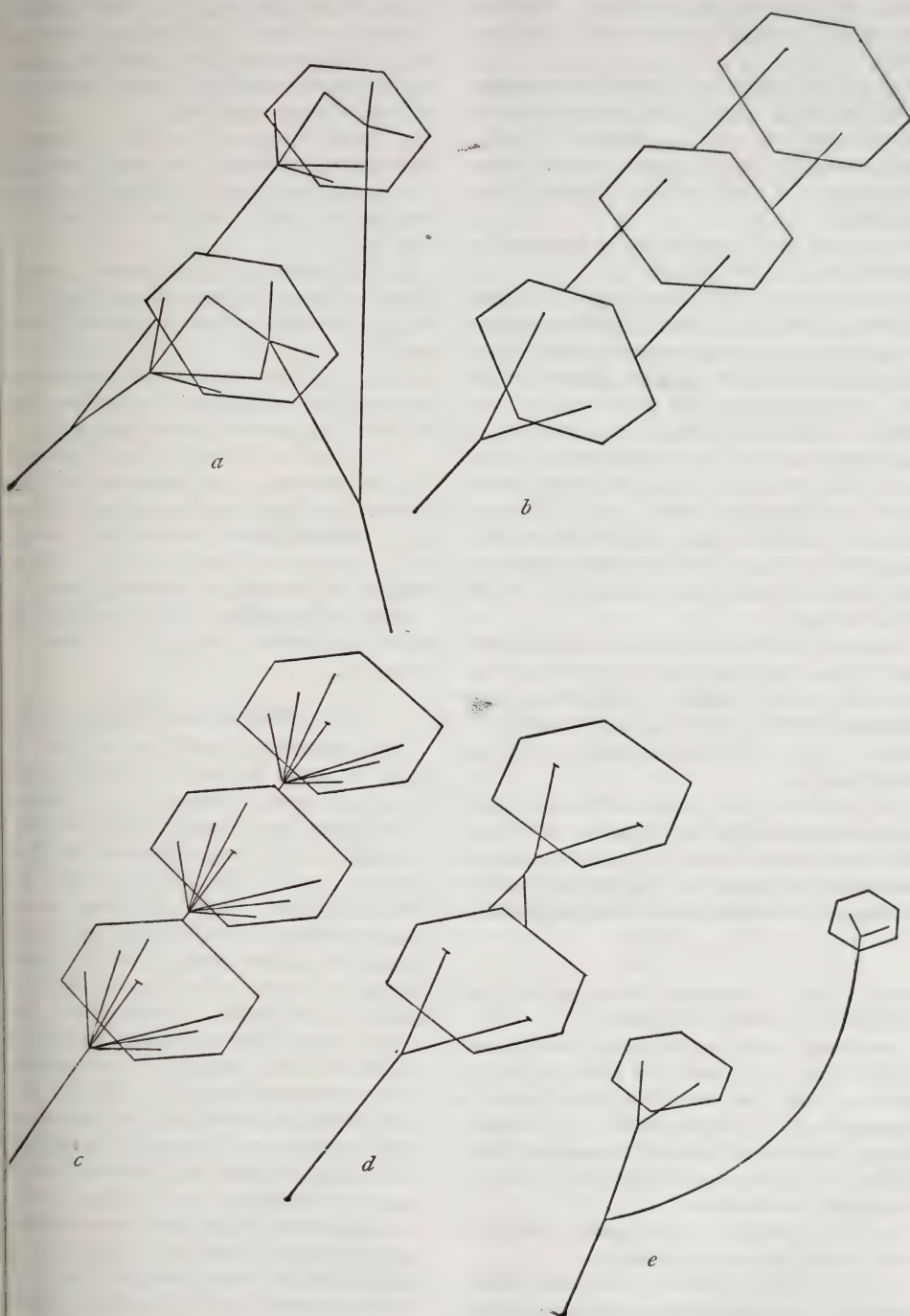


FIG. 2.—METHODS OF CONNECTING SEVERAL KITES.

or cordage I have generally used Italian Russian hemp. Steel wire ought to possess

awkwardness to handle, render hemp preferable.

Let me add a word against all metal clip-hooks, spring swivels, &c., which I at first used much, but soon found to be unreliable, heavy, and generally unsatisfactory. Wooden toggles and eye-splicers are much to be preferred.

I might emphasise the fact that these remarks on the materials used in kite construction are derived from my own experience. Careful experimenters in America have come to other conclusions. (*Vide* Marvin, Millet, Lamson, &c.)

I will now say a few words as regards the practical working of kites.

In very light winds there may be a difficulty in getting a kite up. Then it is best to lay out a long single line along the ground, say 200 or 300 yards long, let one end be attached to the kite, and a man hold the other end and run with it. The kite will thus rise up into the air some 300 or 400 feet, even though it be a dead calm. But often there is a light breeze above which is imperceptible below, and if the kite floats of itself its string may be affixed to a second kite, which it will gradually draw up, and thus a whole series carried up to the upper current.

Even very large kites may be got up in this way. I have several times tried towing such kites with about a dozen men running, or by attaching the kite line to a waggon drawn by horses. By both these methods a man has been lifted up.

The subject of the upper currents of the air has been discussed by Mr. Douglas Archibald, who conducted a series of kite experiments which tend to prove that the velocity always increases with altitude, and in the proportion of

$$\frac{V}{v} = \sqrt[4]{\frac{H}{h}}$$

when V and v represent the velocities, and H and h the corresponding heights.

In strong winds it is usually best to use duplex lines, the ground end fixed to pegs or to trees, &c., so that the wind blows up between them. In strong winds the retaining line or lines should always be securely fixed before the kites are let up, else it may be impossible to hold them.

As far as practical utility goes, I have used kites for the following purposes:—

1. To lift a man similarly to a captive balloon, which may be very useful in military operations as well as for all purposes where a lofty lookout may be desirable. I have actually been lifted up on about eighteen different occasions, sometimes going as high as 100 feet (the limit

of the perpendicular rope). I have also let up weights, equal to that of a man, 300 feet high and I believe that the height attainable is chiefly dependent on the length of rope available. The kite area has varied from 300 to 800 square feet. In most cases I have used from three to eight kites, but have also made ascents with one kite of 500 square feet.

2. To lift a torpedo or large charge explosive to be wafted over a fortification, & I have let up some hundreds of pounds weight and sent it off over a place half-mile off.

3. To take up a photographic camera arranged as to obtain a photograph of the country beneath. I have here some specimens taken.

4. To sail boats, for which purpose kites seem most suitable as the boat can sail very close to the wind, and with no fear of capsizing.

5. To draw a cart, which may be very useful in open country. It is surprising the amount of power the kites possess even in a light wind.

6. Communication between ships at sea, in which letters and parcels can be conveyed without the necessity of lowering a boat.

Also for signalling, getting ropes to otherwise inaccessible places, and many other purposes.

II.—THEORETICAL PRINCIPLES.

The theoretical principles of kite flying seem to have received but little attention from scientists. Professor C. F. Marvin, of Washington, has recently published two monographs, "Kite Experiments at the Weather Bureau," and "The Mechanics and Equilibrium of Kites," which practically constitute the entire literature (in English) on the subject, except for a few remarks in Mr. Chanute's interesting work, "Progress in Flying Machines," and in the "Aëronautical Annual," 1896, while the scientific researches of Professor S. P. Langley ("Aërodynamical") also throw great light on the subject.

In order to investigate the results of the forces acting on a kite we will assume that it is a flat plane, and that the wind blows in a steady, horizontal course. These conditions are practically but seldom met with, the surface usually forming a variety of curves and planes at various angles, while the wind is always variable both in force and direction.

There are two forces acting on the kite in opposition to the retaining line, viz., the weight and the weight of the kite. The wind acts in several ways; it presses on the whole under

face normally to the general plane of the kite; it acts on the front edges and on any projection, tending to drive the kite in the direction of its central vertical axis; and it acts on the retaining line. There may also be a certain amount of "skin friction," though this is probably a very unimportant factor.*

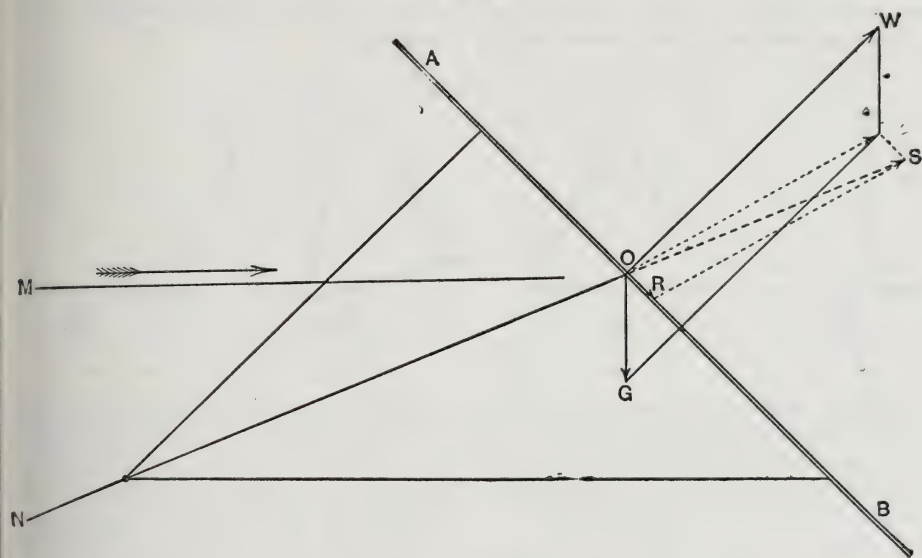
In Fig. 3 let AB represent a vertical section of the kite; OW the wind pressure, which will act at right angles to the plane of the kite; OG represents gravity, or the weight of the apparatus; OR the "frontal pressure," that is, the resistance of the kite and cords and projections to the wind. Then, by completing the parallelogram, we get OS for the total resultant, which gives the force and direction which the string has to oppose in order that the kite shall remain in equilibrium.

to the surface—but it lessens in intensity as the angle presented by the kite becomes smaller, while, on the other hand, the force of gravity or weight remains the same in intensity, but becomes more perpendicular. The frontal pressure, as a rule, increases slightly. Therefore, as the kite approaches the zenith, the total resultant becomes more at right angles. (Fig. 4.)

On starting the kite, the string will naturally be nearly horizontal, as MO. The direction of pull being OS, the kite will rise upward, until the string comes in the position, ON. If it rises above this, it will, of course, be blown back to the position ON.

Hitherto we have taken the point O as the centre of effort of the wind. But in practice this exact point is not easy to find. Moreover,

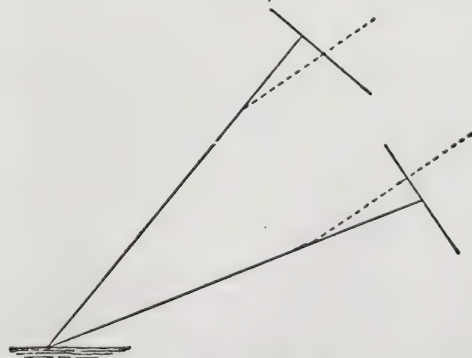
FIG. 3.



From this figure it will readily be apparent that the important relations are the proportionate relations of weight and frontal pressure to the effective wind force, in that, as the latter (OW) increases, the total resultant, or direction of pull, becomes more and more perpendicular to the plane of the kite. Hence, with a heavy kite in a very strong wind, the string will pull at such an angle that the kite cannot rise to any great height. As the kite rises in the air, pivoted about the base of the string, the direction of the wind force remains the same—that is, normal

as will presently be shown, it shifts about

FIG. 4.



according to the angle of the plane. To over-

*The friction of the air is inappreciable. This fact may be stated as the result of my own experiments, and of well-known experiments of others.—Prof. Langley's "Aëronautics."

come this practical difficulty a "bridle" is used. This consists of strings fixed on the kite at points above and below the place of the centre of effort, and connected together in the ground line. The use of the bridle, then, is to automatically adjust the direction of the pull of the string towards the centre of effort.

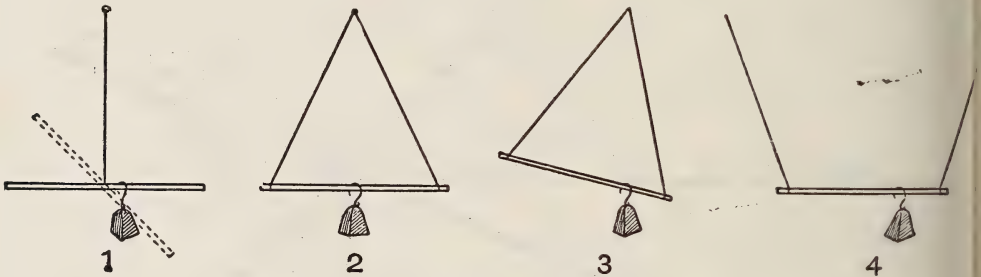
The action of this contrivance can be more easily understood if we suspend a rod horizontally by a piece of string fixed to its centre. If a weight be hooked on to the rod on one side of its centre, it at once tips up. The same occurs with a kite in which the string is affixed to one point—directly the wind force is greater on one side than the other the kite must tip up. But now if we put a bridle on the rod, *i.e.*, suspend it by two strings fixed apart on the stick, and held together above it, a weight can be hooked on to any point between the strings without the rod tipping up to any great extent. Under such circumstances the rod will be inclined until the weight

L being the length of a *square* plane, which may, of course, give a slightly different result to the ordinary shape of a kite.

I have already referred to the "diedral angle of a kite giving stability. The reason for this is easily demonstrated.

A B C (Fig. 6) represent a horizontal section of a kite having a considerable diedral angle. The arrows show the direction of the wind force against the two sides. Now, in strong wind many twirls and eddies are found in the wind currents, just as one sees them in a rapid-flowing river. Such eddies cause uneven pressure to be produced on different parts of a kite. If then a greater pressure is suddenly brought to bear on the side A B, this side is driven back, and a smaller angle is presented to the wind; while the other side, B C, is pressed forward, and, by becoming more at right angles to the direction of the wind, takes a greater pressure, and thus equilibrium is automatically restored.

FIG. 5.



(or rather the centre of gravity of the whole) hangs just below the point of suspension. In the kite this means that such an angle will be presented to the wind that the pull of the string will point towards the centre of pressure.

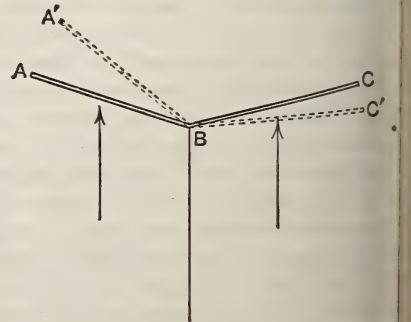
With a plane surface placed at right angles to a current of wind, the centre of the figure will be the centre of effort, and it would be comparatively easy thus to determine the exact centre of effort of any given kite were it not for a law of nature only recently determined, which is, that as a plane presents a less angle to a fluid impinging upon its surface, the centre of pressure *moves forward* towards the front edge of that plane. Therefore, as a kite rises in the air the angle it presents to the wind becomes less, and therefore the centre of pressure shifts forward.

The experiments of Langley, Joëssel, and Kummer practically agree in showing that the centre of effort works forward of the centre of area according to the formula

$$d = (0.3 - 0.3 \sin \alpha) L.$$

It has been pointed out that this form of kite has less tendency to rise high; the reason for this, too, is explicable. The bending back of the sides, of course, diminishes the effective area of the kite—that is, wind-pressure is diminished; but the weight and frontal-pressure remain the same. Hence the result is that pressure acts less perpendicularly.

FIG. 6.



Curved Surfaces.—We began by assuming that the kite was a flat plane, which it seldom

in practice. The action, however, of a current of air impinging on a curved surface is a very little understood. I think we can explain the action of a kite whose whole vertical action consists of one concave curve, and which, as I have said, in practice is always inclined to "top" over into the wind. On the principles already explained, we can understand how the pressures towards the upper portion of the curve, when the surface presents a small angle to the wind, are advanced forward, and that the result will be a strong forward pressure. When the kite has risen to a given height, the angle presented by the front portion of the curve will have become less and less, owing to the direction of the pull on the string, until it is absolutely horizontal, and then not only is there no pressure on the front part of the kite, but the wind will pass over the top, and cause the flexible material to liver and bag, so that all buoyancy is lost, and it then naturally rolls over and spills out wind.

Duplex lines.—The theoretical advantages of "duplex" lines can be explained in the same manner as those of the bridle. If a horizontal section of the kite be taken it will be as if the rod suspended by a string from the centre. If the wind pressure comes on one side the stick or crosspiece of kite is tilted over, and this will at once cause the whole kite to be blown away to one side, and thus in a variable manner the kite will be continually moving from side to side. Directly, however, we suspend the rod by two strings it is apparent that notwithstanding the weight or pressure can cause it to move (see Fig. 5, No. 4).

Tail.—It may be as well to inquire into the reason *d'être* of the tail. It is not likely to have been applied to kites all these years without some reason. Now we know that a badly-constructed kite is liable to turn over and dive to the ground, or swing from side to side. How can this be prevented. If the lower end can be kept down and back the kite cannot capsize. If a heavy weight were attached to the bottom of the kite any irregular movement would set it swinging like a pendulum, and this action would probably be increased until the kite revolved right round. Moreover, the weight would simply tend to pull the kite straight downwards towards the ground. On the other hand if a long light tail were attached, so as to be driven back by the wind, it would have a tendency to pull the kite flat. By contriving, therefore, two, judiciously adding weight to a long tail, the desired result may be obtained of

rectifying the faults of a badly-constructed kite.

It is often difficult to get practice to agree with theory. Thus, for instance, according to theory, if the wind is blowing at about 50 miles an hour, the pressure on a plane surface at right angles to it should be at the rate of 12 lbs. per square foot. Thus on 100 square feet it should be 1,200 lbs. But if the angle be inclined, even to 30° with the horizon, the normal should be '8 of this, that is, 960 lbs. Practically, however, though I have had out kites to test their pull during strong gales, I have no record of a 100 ft. kite ever pulling more than 250 lbs. on the string, and this amount is quite exceptional.

When considering what weight can be lifted by a kite, and to what height it can be raised, the forces acting on the string must be considered. These forces are the weight of the line and the presence of the wind upon it. These cause the line to hang in a curve, more horizontal near the ground and more perpendicular near the kite. The total force thus acting tangent to the string (commonly called the "pull") may be divided into two forces of "lift" and "drift," that is, a force acting vertically upward and one acting horizontally in the direction of the wind. Now it can readily be understood that the "lift" is greater in proportion near the kite than near the ground, while the "drift" may become so great near the ground as to pull the line horizontally, and not even lift it off the ground. But on comparatively short lines and in a good wind this curve is not of importance. We have, however, to consider the effect of hanging a heavy weight on the line. That portion above the weight will remain at the angle caused by the pull of the kite. But the angle of the string below can be readily found.

DISCUSSION.

The CHAIRMAN said the experiments of Captain Powell established a good many facts which had an important bearing on this interesting subject, and the explanations he had given were very clear. He had had the privilege of seeing and taking part in some of the experiments carried out last week at Hounslow, and seeing how the kites actually performed. As was shown in one of the slides, the kites were sometimes rather unsteady, and swayed about; the fact was that the wind was very variable indeed, and although at the surface of the ground it might seem to be steady, yet when tested by these kites a little way up, it did not remain steady many minutes

together. Some of the principles which had been established by Captain Powell, as, for instance, the application of two strings to keep the kite steady and guide it, and make it fly even at an angle to the wind, were very important in practice. A kite which would only fly in the direction of the wind would be of comparatively little service, because it seldom happened that the wind blew exactly in the required direction. He was hardly prepared to find that so much had been already accomplished, and was very glad that the subject of aeronautics had advanced so far within the last three or four years. Kites would be useful, not only for military purposes but also to travellers, and he had no doubt that if Nansen had had kites which were easy of manipulation he would have been able much more readily to overcome some of the difficulties he met with in his Arctic expedition. In connection with sledging he should think they would be of great use, and would be available where balloons were out of the question. An international conference on the subject of aeronautics was shortly to be held at Strassburg, when the use of balloons and kites would be discussed, chiefly in connection with meteorology, with the view of selecting a number of stations where observations might be made simultaneously on the physical phenomena of the atmosphere over a large area.

Mr. R. H. SCOTT, F.R.S., said a special committee had been appointed at the Meteorological Conference in Paris in 1896 to study the question of simultaneous balloon ascents for the purpose of making observations, some carrying human observers, and others only instruments, and, on three occasions, balloons had been started at the same time from Paris, Strassburg, Berlin, Munich, and in one or two cases from St. Petersburg, in order as it were to take soundings of the atmosphere on the same day at different points. He had received notice of a meeting of this committee, which was to be held at the end of the month, from Dr. Hergesell, the head of the Meteorological Institute at Strassburg, chairman of the committee, and also signed by the well-known name of Monsieur de Fonvielle. He saw that one particular section of the programme was devoted to the use of kites, for which Mr. Rotch was going to furnish an account of his experiences at Blue Hill. The committee would deal particularly with a form of apparatus, the kite-balloon, of which he believed the inventor was present. He understood that an ascent was to be made with one of these kite-balloons during the conference. He should be glad to receive papers from any one who had anything to communicate to the conference, and, if sufficient notice were given him, to procure invitations. They were much indebted to Captain Baden-Powell for the trouble he had taken in preparing the paper.

Mr. DOUGLAS ARCHIBALD said he had been much interested in hearing the experience of Captain Powell, which seemed to bear out practically results which Professor Marvin had deduced theoretically, as stated

in his recent work, and he must say that in these matters he preferred the deductive to the inductive method. He considered Professor Marvin's work on kites was perhaps the best handbook on the subject, and he had done good service in working out the theory so fully. Captain Powell had dealt more with the kites themselves than their applications, on which subject he thought there was room for another paper. There was an immense field open in that direction for this was a science which had been too long neglected. Until he first resuscitated kite flying in 1883 it had been buried in oblivion since 1844. He had recently tried to interest the War Office but was told that the military authorities did not think it necessary to experiment any further. He was sorry to hear that, because he thought if the experiments had been carried a little further, in all probability some very practical results would have been attained. In the recent Tirah campaign a few kites with cameras attached to them, would have been of very great use, and might have given information as to what was going on at the other side of some of those very steep and inaccessible hills. He had lately been thinking out one or two forms of apparatus by which this could be accomplished and was confident that it would be quite possible. Some people might have doubts about it, but, in any rate, there could be no harm in trying. The Hargrave kite exhibited was not quite as it was described by the inventor. He met Mr. Hargrave in Australia, and spent an afternoon with him in flying his kite. The front and back were fastened together with wires or bamboos, and there were also cross struts, so that the whole thing was rigid. It was probable that Captain Powell's kites were lighter, but he thought that some form of the Hargrave was the most satisfactory, especially in a heavy breeze, but he had not seen Captain Powell's in action and could not therefore judge of their relative merits. He agreed that bamboo was by far the best material to use. People often said, how could you get up a kite when there was no wind? but that was a pure assumption. We were at the bottom of an aerial ocean, and very few knew what was going on above. Some years ago—in 1883, 1884, and 1885—he made a great many experiments, and he remembered that frequently his kites were up in the air pulling tremendously, when he could have lit a match without the slightest flickering where he was standing. That usually occurred at night, and it had been shown by Professor Marvin and others that night was the best time for flying kites, though it might not be the most convenient. During the day the air was never disturbed. There was a question of the apparent discrepancy between observation and theory with regard to the pressure and lifting power which ought to be cleared up. He believed it arose in getting the measure from continuing to use an old formula, which had been shown to be erroneous, the coefficient being really '0026 instead of '005. The whole subject was one which required working at rather than

king about, and he should like to see more people paying attention to it, and applying it in various ways. It was already used for photography, and he had heard recently from naval officers that it would be very useful for communication between ships at sea. For scientific purposes generally, it would undoubtedly come into use for ascertaining pressures and temperatures at great heights. In America he saw they were planning a series of kites at high levels, so as to form isobaric charts at an elevation of 5,000 feet, which seemed rather a bold idea. When he was at Hue Hill, on one occasion he superintended the kite flying, when they elevated a barograph to a height of 300 feet, and after he left they reached as high as 9,000 feet. When they could carry recording instruments to heights like that, it seemed to him they were running balloons rather hard. Captain Powell said he was not certain whether it was more advantageous to use large kites, or small, and he agreed that it was a matter on which you had to compromise. A large kite was more useful and convenient but small ones were more portable. Mr. Arggrave once said that he thought a man with five kites under his arm could ascend from the top of an omnibus. It would be rather an uncomfortable race to start from, probably; but his idea was to show the degree of portability possible. He was rather in favour of large kites himself, as they flew better; but, if for other reasons it was desirable to have several smaller ones, it was best to have, say, three at the top and one or two below. It had been shown by theory, and he believed it would be found in practice, that the best arrangement for kites in tandem was to have a bunch at the top, and then the others seriatim below. The greatest pull was obtained where you got the greatest velocity, and the total lifting power was greater with such an arrangement. Since he invented the kite-balloon some years ago he had not touched the subject at all, but when in Germany last year, he heard that a kite-balloon of some form had been adopted by someone, and hoped it would prove successful. He could not help thinking that the idea had something in it. A balloon rose in a calm, and a kite rose in a wind, and when you had something between a wind and a calm, a combination of the two seemed to be the right thing. When the wind dropped, the balloon kept the kite up, and when the wind rose the kite had a tendency to keep the balloon up. His plan was to have a balloon with a kite fastened in front of it in such a way that the kite shielded the balloon from the effect of the wind. In fact, the late Mr. Charles Spencer once told him that he thought of it as a balloon shield. The balloon must not rise much above the kite, otherwise the wind, being horizontal, would have a tendency to pull the balloon away from the kite, so that the balloon must be rather smaller in section. The fastening was effected by means of straps from the top of the balloon. It was described and figured in *Nature* in 1884.

Colonel ALLAN CUNNINGHAM said it was rather curious that the toys of a thousand years ago should be now utilised for military purposes, but it was not quite correct to say that kites were only now being used for the purpose of traction, because he had read of their being used to draw carriages and boats long ago. The modern use of the war balloon also, he believed, proceeded from a toy. The combination of the two was very interesting, because the captive balloon was at its best in calm weather, and was very different, and indeed dangerous, to use in a high wind, whereas a kite was difficult to use in a light wind, and was at its best in a strong wind. In these kites they saw a very pretty adaptation of means to ends—the shape of the kite, the shape and the disposition of the frame, and the combination of cords. One of the greatest advances seemed to be in the adoption of a number of cords, which secured that great desideratum, steadiness. He had seen them flying, and those which were high up were very steady, and even those low down, probably in consequence of these attachments, were fairly steady also. On the other hand, the number of cords introduced certain practical difficulties, each point of attachment being a source of weakness, and on each occasion when he had seen a public exhibition something gave way, either a cord or its attachment, and the kite got out of its proper position. If there was a man up in a car this might be dangerous. The exhibition to which he referred was at Ipswich, and there was a very large crowd present, which probably was not favourable to success. The kite-balloon was also very interesting, but he must confess it was rather ugly to look at, and a balloon being such a delicate object, he always had a fear that it might be injured if anything gave way in the framework of the kite.

Mr. W. F. REID said he happened to be present at Ipswich when the kites went up, and though there was a little hitch at the beginning, he thought it was due to the pressure of the crowd, which led to the rope being pulled at the wrong moment. The defect was soon remedied however, and they went up all right. He had the pleasure of going up about 100 feet in the basket. He thought the portability of the apparatus had hardly been sufficiently dwelt upon. On the occasion in question, he saw the whole thing being taken into the park on a costermonger's barrow. This was a matter of great importance for military purposes, and he agreed with Mr. Archibald in thinking it was a great pity that some of these kites were not available in the war on the Indian frontier. One mule would have been quite sufficient to carry everything necessary to enable our brave soldiers to see what the enemy was doing. The system of double lines which gave the power of altering the angle and adapting the position of the kites to the strength of the wind was of the greatest importance. The tail, which had constantly to be added to or shortened, was always a nuisance, and it was a great thing to get rid of it altogether. With regard to the lifting power not being so great as

s varnished with water glass (*wasserglas*), 40 per cent. bad. (12) Eggs varnished with collodion, 40 per cent. bad. (13) Eggs covered with lac, 40 per cent. bad. (14) Eggs varnished with various mixtures, 20 per cent. bad. (15) Eggs preserved in water of wood, 20 per cent. bad. (16) Eggs treated with boric acid and water glass, 20 per cent. bad. Eggs treated with potassium manganate, 20 per cent. bad. (18) Eggs varnished with vaseline, all good. (19) Eggs preserved in lime water, all good. Eggs preserved in a solution of water glass, all good. The last three methods are consequently to be considered the best ones, and especially the preservation in a solution of water glass, as varnishing eggs with vaseline takes too much time, and the treatment with lime water sometimes communicates to the eggs a disagreeable odour and taste. There is, however, to be one drawback with eggs preserved in a solution of water glass, namely, that the shell easily bursts in boiling water. This may be avoided by carefully piercing the shell with a strong needle.

General Notes.

TRAFFIC IN THE SUEZ CANAL.—The number of vessels which passed through the Suez Canal during the five months ending December 31 last was 2,986, as compared with 3,409 in 1896, and 3,434 in 1895. Receipts show a corresponding falling off—having amounted to 72,836,830 fr. in 1897, as compared with 69,994 fr. in 1896, and 78,103,718 fr. in 1895.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock:—

MARCH 9.—“Linde’s Method of Producing Ice Cold and Liquefying Air.” By Professor J. EWING, F.R.S. Professor JAMES DEWAR, D., F.R.S., will preside.

MARCH 16.—“The Recent History of Paper-making.” By CLAYTON BEADLE.

MARCH 23.—“The Preparation of Meat Extracts.” By C. R. VALENTINE.

MARCH 30.—“Telegraphy Across Space.” By Professor SILVANUS P. THOMPSON, F.R.S. J. W. L. N., F.R.S., will preside.

Dates to be hereafter announced:—

Stage Mechanism.” By EDWIN O. SACHS.

Water Gas and its Appliances.” By Professor AN LEWES.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock:—

MARCH 10.—“India and Sir Henry Maine.” By CHARLES LEWIS TUPPER, C.S.I. The Right Hon. Sir MOUNTSTUART ELPHINSTONE GRANT, F.R.S., will preside.

MARCH 31.—“The Earthquake in Assam.” By HENRY LUTTMAN-JOHNSON, I.C.S. The Right Hon. Sir HENRY FOWLER, G.C.S.I., M.P., will preside.

APRIL 21.—“Recent Railway Policy in India.” By HORACE BELL, M.Inst., C.E.

** The paper by Mr. Karkaria previously announced has been unavoidably postponed.

APRIL 28.—“India and Currency.” By Sir EDWARD SASSOON, Bart.

MAY 19.—“Chartered Companies and Colonisation.” By Sir ALFRED COMYNS LYALL, G.C.I.E., K.C.B., D.C.L. (Member of the Council of India).

The meeting of March 31 will be held at the Imperial Institute; those of March 10, April 21, April 28, and May 19 at the Society of Arts.

FOREIGN AND COLONIAL SECTION.

Tuesday Afternoons, at 4.30 o'clock:—

MARCH 15.—“The West Indies and Sugar Bounties.” By NEVILLE LUBBOCK.

Date to be hereafter announced:—

“The African: what he is, and what he is capable of becoming.” By the Rev. GODFREY DALE (Universities Mission to Central Africa).

APPLIED ART SECTION.

Tuesday Evenings, at Eight o'clock:—

MARCH 8.—“The Making of a Stained Glass Window.” By LEWIS FOREMAN DAY. WALTER CRANE will preside.

MARCH 29.—“English Art in Illuminated MSS.” By Sir EDWARD MAUNDE THOMPSON, K.C.B.

APRIL 26.—“The Importance of Craftmanship.” By Sir WILLIAM BLAKE RICHMOND, R.A., K.C.B.

MAY 10.—“The Art of William Morris.” By F. S. ELLIS.

MAY 17.—“Practical Points in Italian Majolica Painting.” By WILLIAM BURTON, F.C.S.

CANTOR LECTURES.

Monday Evenings, at Eight o'clock:—

HUGH STANNUS, “The Principles of Design in Form.” Four Lectures.

LECTURE IV.—MARCH 7.—Simplicity, Reticence, Unity, &c.

PROF. W. NOEL HARTLEY, F.R.S., “The Thermo-Chemistry of the Bessemer Process.” Three Lectures.

LECTURE I.—MARCH 14.

Introduction and historical notes—The description and chemical technology of the process—Plant used—Modified forms of converters—Fixed and moveable vessels—Side-blown and bottom-blown charges—

Recent modifications, as the Robert, Tropenas, and Walrand-Légénisiel processes—Evolution of heat during the “blow.”

LECTURE II.—MARCH 21.

The course of chemical change in the “blow”—Thermo-chemical data—Thermo-chemical data in their application to metallurgical operations—Assumed composition of pig-iron—Calculations applied to the “acid” and the “basic” processes—Other calculations—Temperature of the metal—The study of the Bessemer flame and its spectrum.

LECTURE III.—MARCH 28.

The “acid” process—Variations in the flame and spectrum during the different periods of the “blow”—Variations in temperature during successive intervals in the “boil” and “fining” stages—The “basic” process—Differences in the flame and the spectrum—Marked difference in the flame of the “over-blow”—Substances discovered in the flame traced from the basic charge to the ore.

DR. D. MORRIS, C.M.G., “India Rubber.”
Two Lectures.

April 18, 25.

PROF. CARUS WILSON, “Electric Traction.”
Four Lectures.

May 2, 9, 16, 23.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 7 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Mr. Hugh Stannus, “The Principles of Design in Form.” (Lecture IV.)
Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.
Engineers, in the Theatre of the United Service Institution, Whitehall, S.W., 7½ p.m. Mr. William Fox, “Reservoir Embankments, with suggestions for avoiding and remedying failures.”
Imperial Institute, South Kensington, 8½ p.m. Mr. J. H. Collins, “The Mineral and other Resources of Newfoundland.”
Surveyors, Savoy-street, Strand, W.C., 8 p.m. Mr. W. Irvine, “Land Survey and Valuation in Northern India.”
Sanitary Institute, 74A, Margaret-street, W., 8 p.m. Prof. A. Bostock Hill, “Trade Nuisances.”
Camera Club, Charing-cross-road, W.C., 8½ p.m. Mr. Clinton Dent, “On the Caucasus.”
Medical, 11, Chandos-street, W., 8½ p.m.
Victoria Institute, 8, Adelphi-terrace, W.C., 4½ p.m. Mr. Gerrard Smith, “The Design of the Human Foot.”

TUESDAY, MARCH 8...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Applied Art Section.) Mr. Lewis Foreman Day, “The Making of a Stained Glass Window.”
Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. Ray Lankester, “The Simplest Living Thing.” (Lecture VIII.)
Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.
Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Papers to be further discussed:—(a)

Mr. Llewelyn B. Atkinson, “The Theory, Design and Practical Working of Alternate Current Motors;” (b) Mr. H. F. Parshall, “Dublin Electric Tramway.” 2. Mr. Henry Fowler, “Calcium Carbide and Acetylene.”

Photographic, 12, Hanover-square, W., 8 p.m. Mr. A. Haddon, “The Passage of a few of the Salts used in Photography through Gelatine Septa.”

Anthropological, 3, Hanover-square, W., 8½ p.m.

Colonial Inst., Whitehall-rooms, Whitehall-place, S.W., 8 p.m. Mr. George Carrington, “Our West Indian Colonies.”

Asiatic, 22, Albemarle-street, W., 4 p.m.

Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m.

Designers, Clifford's Inn, E.C., 8 p.m. Mr. S. Proverbs, “Design for Wall Papers.”

WEDNESDAY, MARCH 9...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Prof. J. Ewing, “Lind Method of Producing Extreme Cold and Liquefying Air.”

Geological, Burlington-house, W., 8 p.m.

Sanitary Institute, 74A, Margaret-street, W., 8 p.m.

Dr. Christopher Child, “Water-Borne Typhoid.”
Royal Literary Fund, 7, Adelphi-terrace, W.C., 3 p.m. Annual Meeting.

Royal Society of Literature, 20, Hanover-square, W., 1 p.m.

Junior Engineers, 9, Conduit-street, W., 7½ p.m.

Joint Meeting with the Architectural Association.
Messrs. Sydney Beale and Percy Waldram, “The Desirability for Closer Relationship between Architect and the Engineer.”

THURSDAY, MARCH 10...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Indian Section.) Charles Lewis Tupper, “India and Sir Henry Maine.”

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

United Service Institution, Whitehall, S.W., 3 p.m. Captain W. H. James, “The Nation and Army.”

Society for the Encouragement of Fine Arts, Conversation at the Royal Institution of Painters.
Watercolours, Piccadilly, 8 p.m.

Sanitary Inst., 74A, Margaret-street, W., 8 p.m.

Dr. J. F. J. Sykes, “Objects and Methods of Inspection, &c.”

Royal Institution, Albemarle-street, W., 3 p.m.

Prof. J. A. Fleming, “Recent Researches in Magnetism and Diamagnetism.” (Lecture II.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Mr. Binswanger-Birnbaum's paper, “The Manufacture of Lamp and other Apparatus for 200 Volt Circuits.”

Mathematical, 22, Albemarle-street, W., 8 p.m.

Camera Club, Charing-cross-road, W.C., 8½ p.m.

FRIDAY, MARCH 11...Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Mr. W. Freeland, “Marked Unexplored.”

Civil Engineers, 25, Great George-street, S.W., 8 p.m. (Students' Meeting.) Mr. H. C. Adams, “The Drainage of Cottage Property.”

Astronomical, Burlington-house, W., 3 p.m.

Clinical, 20, Hanover-square, W., 8½ p.m.

Physical, Chemical Society's Rooms, Burlington-house, W., 5 p.m. 1. Prof. J. D. Everett, “Optical Illustrations of certain Optical Phenomena.” 2. Mr. R. A. Lehfeldt, “Properties of Liquid Mixtures.”

SATURDAY, MARCH 12...Botanic, Inner Circle, Regent's-park, N.W., 3½ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. Walter Raleigh, “English Letter Writing.” (Lecture II.)

Journal of the Society of Arts.

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FRIDAY, MARCH 11, 1898.

communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.

CANTOR LECTURES.

The fourth (and last) lecture of his course "The Principles of Design in Form" was delivered by Mr. HUGH STANNUS, F.R.I.B.A., Monday evening, 7th inst. A vote of thanks to the lecturer was passed on the motion of the CHAIRMAN.

The lectures will be printed in the *Journal* during the summer recess.

APPLIED ART SECTION.

Tuesday, March 8, 1898; WALTER CRANE in the chair.

The paper read was "The Making of a Painted Glass Window." By Lewis Foreman.

The report of the meeting will be published in the number of the *Journal* for March 25th.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal for 1898 early in the next, and they, therefore, invite members of the Society to forward to the Secretary, on or before the 9th of April, the names of such persons of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit for promoting Arts, Manufactures, or Commerce," and has been awarded as follows in previous years:—

In 1864, to Sir Rowland Hill, K.C.B., F.R.S., for his great services to Arts, Manufactures, and Commerce, in the creation of the penny postage, and in other reforms in the postal system of this country, the benefits of which have, however, not been confined to this country, but have extended over the civilised world."

In 1865, to his Imperial Majesty, Napoleon III., "for distinguished merit in promoting, in many ways, by his personal exertions, the international progress of Arts, Manufactures, and Commerce, the proofs of which are afforded by his judicious patronage of Art, his enlightened commercial policy, and especially by the abolition of passports in favour of British subjects."

In 1866, to Michael Faraday, D.C.L., F.R.S., "for discoveries in electricity, magnetism, and chemistry, which, in their relation to the industries of the world, have so largely promoted Arts, Manufactures, and Commerce."

In 1867, to Mr. (afterwards Sir) W. Fothergill Cooke and Professor (afterwards Sir) Charles Wheatstone, F.R.S., "in recognition of their joint labours in establishing the first electric telegraph."

In 1868, to Mr. (afterwards Sir) Joseph Whitworth, LL.D., F.R.S., "for the invention and manufacture of instruments of measurement and uniform standards by which the production of machinery has been brought to a state of perfection hitherto unapproached, to the great advancement of Arts, Manufactures, and Commerce."

In 1868, to Baron Justus von Liebig, Associate of the Institute of France, For. Memb. R.S., Chevalier of the Legion of Honour, &c., "for his numerous valuable researches and writings, which have contributed most importantly to the development of food economy and agriculture, to the advancement of chemical science, and to the benefits derived from that science by Arts, Manufactures, and Commerce."

In 1870, to Vicomte Ferdinand de Lesseps, Member of the Institute of France, Hon. G.C.S.I., "for services rendered to Arts, Manufactures, and Commerce, by the realisation of the Suez Canal."

In 1871, to Mr. (afterwards Sir) Henry Cole, K.C.B., "for his important services in promoting Arts, Manufactures, and Commerce, especially in aiding the establishment and development of International Exhibitions, the Department of Science and Art, and the South Kensington Museum."

In 1872, to Mr. (now Sir) Henry Bessemer, F.R.S., "for the eminent services rendered by him to Arts, Manufactures, and Commerce, in developing the manufacture of steel."

In 1873, to Michel Eugène Chevreul, For. Memb. R.S., Member of the Institute of France, "for his chemical researches, especially in reference to saponification, dyeing, agriculture, and natural history, which for more than half a century have exercised a wide influence on the industrial arts of the world."

In 1874, to Mr. (afterwards Sir) C. W. Siemens, D.C.L., F.R.S., "for his researches in connection with the laws of heat, and the practical applications of them to furnaces used in the Arts; and for his improvement in the manufacture of iron; and generally for the services rendered by him in connection with economisation of fuel in its various applications to Manufactures and the Arts."

In 1875, to Michel Chevalier, "the distinguished

French statesman, who, by his writings and persistent exertions, extending over many years, has rendered essential services in promoting Arts, Manufactures, and Commerce."

In 1876, to Sir George B. Airy, K.C.B., F.R.S., late Astronomer Royal, "for eminent services rendered to Commerce by his researches in nautical astronomy and in magnetism, and by his improvements in the application of the mariner's compass to the navigation of iron ships."

In 1877, to Jean Baptiste Dumas, For. Memb. R.S., Member of the Institute of France, "the distinguished chemist, whose researches have exercised a very material influence on the advancement of the Industrial Arts."

In 1878, to Sir Wm. G. Armstrong (now Lord Armstrong), C.B., D.C.L., F.R.S., "because of his distinction as an engineer and as a scientific man, and because by the development of the transmission of power—hydraulically—due to his constant efforts, extending over many years, the manufactures of this country have been greatly aided, and mechanical power beneficially substituted for most laborious and injurious labour."

In 1879, to Sir William Thomson (now Lord Kelvin), LL.D., D.C.L., F.R.S., "on account of the general service rendered to Arts, Manufactures, and Commerce, by his electrical researches, especially with reference to the transmission of telegraphic messages over ocean cables."

In 1880, to James Prescott Joule, LL.D., D.C.L., F.R.S., "for having established, after most laborious research, the true relation between heat, electricity, and mechanical work, thus affording to the engineer a sure guide in the application of science to industrial pursuits."

In 1881, to August Wilhelm Hofmann, M.D., LL.D., F.R.S., Professor of Chemistry in the University of Berlin, "for eminent services rendered to the Industrial Arts by his investigations in organic chemistry, and for his successful labour in promoting the cultivation of chemical education and research in England."

In 1882, to Louis Pasteur, Member of the Institute of France, For. Memb. R.S., "for his researches in connection with fermentation, the preservation of wines, and the propagation of zymotic diseases in silkworms and domestic animals, whereby the arts of wine-making, silk production, and agriculture have been greatly benefited."

In 1883, to Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S., "for the eminent services which, as a botanist and scientific traveller, and as Director of the National Botanical Department, he has rendered to the Arts, Manufactures, and Commerce by promoting an accurate knowledge of the floras and economic vegetable products of the several colonies and dependencies of the Empire."

In 1884, to Captain James Buchanan Eads, "the distinguished American engineer, whose works have

been of such great service in improving the communications of North America, and have thereby rendered valuable aid to the commerce of the world."

In 1885, to Mr. (afterwards Sir) Henry Doulton, recognition of the impulse given by him to the production of artistic pottery in this country."

In 1886, to Samuel Cunliffe Lister (now Lord Masham), "for the services he has rendered to textile industries, especially by the substitution of mechanical wool combing for hand combing, and the introduction and development of a new industry—the utilisation of waste silk."

In 1887, to HER MAJESTY THE QUEEN, "in commemoration of the progress of Arts, Manufactures, and Commerce throughout the Empire during fifty years of her reign."

In 1888, to Professor Herman Louis Helmholtz, For. Memb. R.S., "in recognition of the value of his researches in various branches of science and their practical results upon music, painting, and useful arts."

In 1889, to John Percy, LL.D., F.R.S., "for his achievements in promoting the Arts, Manufactures, and Commerce, through the world-wide influence of which his researches and writings have had upon the progress of the science and practice of metallurgy."

In 1890, to William Henry Perkin, F.R.S., "for his discovery of the method of obtaining colouring matter from coal tar, a discovery which led to the establishment of a new and important industry, and to the utilisation of large quantities of a previously worthless material."

In 1891, to Sir Frederick Abel, Bart., K.C.B., D.C.L., D.Sc., F.R.S., "in recognition of the manner in which he has promoted several important classes of the Arts and Manufactures, by the application of his researches to Chemical Science, and especially by his researches in the manufacture of iron and of steel; and in acknowledgment of the great services he has rendered to the State in the provision of improved war material, and as Chemist to the War Department."

In 1892, to Thomas Alva Edison, "in recognition of the merits of his numerous and valuable inventions, especially his improvements in telegraphy, in telephony, and in electric lighting, and for his discovery of a means of reproducing vocal sounds by the phonograph."

In 1893, to Sir John Bennet Lawes, Bart., F.R.S., and Sir Henry Gilbert, Ph.D., F.R.S., "for their joint services to scientific agriculture, and notably the researches which, throughout a period of thirty years, have been carried on by them at the Experimental Farm, Rothamsted."

In 1894, to Sir Joseph (now Lord) Lister, F.R.S., "for the discovery and establishment of the antiseptic method of treating wounds and injuries by which not only has the art of surgery being generally promoted, but human life saved in all parts of the world, and extensive industries have been created for the supply of antiseptics."

of materials required for carrying the treatment into effect."

In 1895, to Sir Isaac Lowthian Bell, Bart., F.R.S., "in recognition of the services he has rendered to Arts, Manufactures, and Commerce by his metallurgical researches and the resulting development of the iron and steel industries."

In 1896, to Prof. David Edward Hughes, F.R.S., "in recognition of the services he has rendered to Arts, Manufactures, and Commerce, by his numerous inventions in electricity and magnetism, especially the printing telegraph and the microphone."

In 1897, to George James Symons, F.R.S., "for the services he has rendered to the United Kingdom by affording to engineers engaged in the water supply and the sewage of towns a trustworthy basis for their work, by establishing and carrying on during nearly forty years systematic observations (now at over 3,000 stations) of the rainfall of the British Isles, and by recording, tabulating, and graphically indicating the results of these observations in the annual volumes published by himself."

The Council invite Members of the Society to forward to the Secretary, on or before the 8th of April, the names of such men of high distinction as they may think worthy of this honour.

Proceedings of the Society.

THIRTEENTH ORDINARY MEETING.

Wednesday, March 2, 1898; Prof. JAMES EWAR, LL.D., F.R.S., Pres. Chem. Soc., in the chair.

The following candidates were proposed for election as members of the Society:—

1, Horace, 28, Victoria-street, S.W.
bree, Harry Hankey, 34, De Vere - gardens, Kensington, W.

The following candidates were balloted for and duly elected Members of the Society:—

ce, Major Robert N. D., Messrs. Vickers, Sons and Maxim, Limited, Sheffield.
per, John Duncan Campbell, B.A., 80, Grosvenor-street, W.

ggs, C. H., Elm-tree-house, Macaulay-road, Clapham, S.W.

ns, P. F. Sparke, J.P., Trinmore, Clifton Down, Bristol.

field, Frederick N., P.O. Box 211, Durban, Natal, S. Africa.

onjee, Nowrojee, Ahmedabad, India.

Remington, John Stewart, Dromore, Milverton, Leamington.

Worth, Frederick Gouner, 63, Queen Victoria-street, E.C.

The paper read was—

LINDE'S METHOD OF PRODUCING EXTREME COLD AND LIQUEFYING AIR.

BY PROF. J. A. EWING, F.R.S., M.INST.C.E.

In May, 1895, Dr. Carl Linde, of Munich, whose earlier services to refrigeration in the development of the ammonia compression machine are widely known, made public a novel process which he had invented for attaining extremely low temperatures and for liquefying air. By his method the production of liquid air is so much simplified that its application to industrial uses is comparatively easy. Industrial uses are in fact now being found for the process, and at Dr. Linde's request I have undertaken to bring it before the Society of Arts and to speak briefly of the applications to which it is now being or about to be put. The inventor's son, Dr. F. Linde, has come from Munich to exhibit the apparatus in action.

From the industrial point of view the liquefaction of air is likely to prove valuable mainly because it gives a means of separating more or less completely the oxygen of the atmosphere from its associated nitrogen. When air is liquefied it is noticed, as Professor Dewar has remarked, that both constituents liquefy together, so that the act of becoming liquid does not contribute to separate them. But when liquefied air evaporates, the nitrogen evaporates faster than the oxygen, for it boils at a temperature which is about 13° C. lower than the boiling point of oxygen. Hence the mixture of liquefied gases becomes richer and richer in oxygen as the process of evaporation goes on. By letting a considerable part of the liquid evaporate, a liquid remainder is left which may consist largely of oxygen; and by letting this remainder evaporate an atmosphere rich in oxygen is obtained.

Dr. Linde has given me the following figures, deduced from his own experiments, which show how the constitution of the liquid changes during slow evaporation. In the Table *m* is the per-centage of the whole liquid which remains at each stage in the evaporation; *a* is the per-centage of oxygen in it; *b* is the per-centage of oxygen in the vapour then

coming off, and n is the per-centage of the original quantity of oxygen which still remains in the liquid.

m Per Cent. of Liquid not yet Evaporated.	a Per Cent. of Oxygen in Liquid.	b Per Cent. of Oxygen in Vapour coming off.	n Per Cent. of Original Oxygen still in Liquid.
100	23.1	7.5	100
50	37.5	15	80
30	50	23	65
20	60	34	52
15	67.5	42	43
10	77	52	33
5	88	70	19

These results are also given in the curves of Fig. 1.

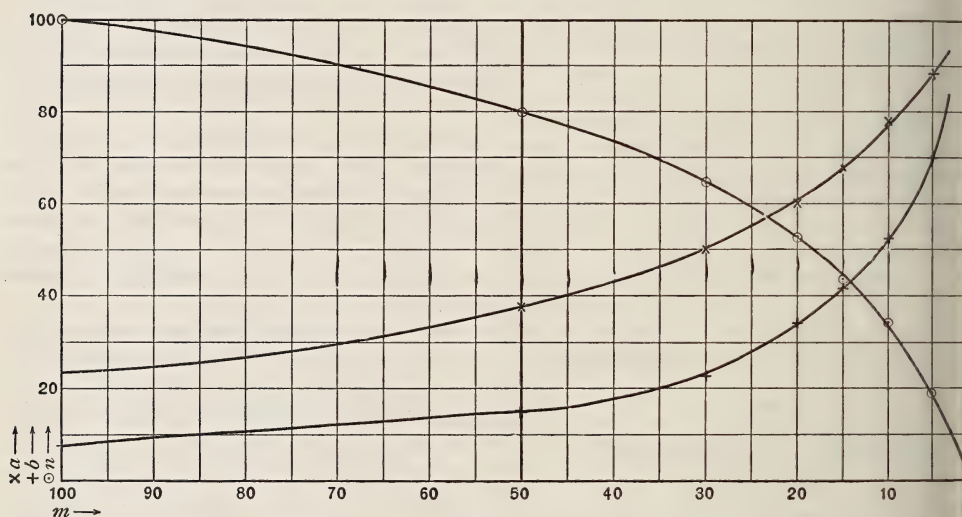


FIG. 1.

Thus, for example, by the time 70 per cent. of the liquid has disappeared in quiet evaporation, the remainder (*viz.*, 30 per cent.) contains 50 per cent. of oxygen. The gas then coming off contains 23 per cent. of oxygen. And out of the whole quantity of oxygen which was present in the original liquid 65 per cent. is still there. I understand these figures were obtained by examining the proportion present in the gas given off at each stage: in other words, the points in the curve b were found by experiment, and the other quantities were deduced by calculation from these.

It is only when evaporation is going on very quietly that these results hold good. Anything like violent boiling has the effect of carrying off the oxygen more rapidly, and consequently of preventing, to some extent, the enrichment of the residual liquid. When this method of

separating oxygen from nitrogen is carried out on a commercial scale, the evaporation cannot well take place so quietly as it took place in these experiments. Dr. Linde tells me that when working under practical conditions he has to allow about four-fifths of the liquid to evaporate in order that the residue should contain 50 per cent. of oxygen. Even then, however, some 40 to 45 per cent. of the original oxygen remains in the unevaporated liquid.

Before going on to speak of the uses to which the oxygen procured in this way may be put, the process itself must be described. In all methods of liquefying a gas the first essential is to reach a temperature lower than the critical temperature of the gas. For nitrogen this temperature is about -140° C. Such a

temperature, or one still lower, may be reached by evaporating liquid ethylene in vacuo, and hence air may be liquefied by compressing it into a surface condenser, which is cooled by the evaporation of liquid ethylene, while the vapour of the ethylene is removed by a pump. A separate compressing pump restores the ethylene vapour to the liquid state by compressing it into another condenser, which is cooled by the evaporation of liquid carbonic acid, and that again is compressed by a third pump into a third condenser, which is cooled by circulating water. Such a cascade, as it may be called, of pumps and condensers was first furnished (previous to Dr. Linde's invention) as the only practicable method of liquefying nitrogen in any considerable quantity, and it was by means of apparatus such as this that Professor Dewar carried out his remarkable experiments

which have made the laboratory of the Royal Institution pre-eminently the home of liquid air.

Dr. Linde's method is entirely different from his. It is a regenerative method; that is to say, the cold produced by the treatment of one portion of air is communicated to the portion which is next coming on to be treated, and so on, with the result that a cumulative cooling proceeds, which is only limited by the leakage of heat into the apparatus from outside.

Imagine air, or any other gas, to be pumped round and round a closed system of pipes, and imagine that at one place in the system it suffers a drop in temperature through some internal action. Imagine, further, that the air which has suffered this drop in temperature is led back to the pump through a pipe, which is brought into close contact with the pipe conveying air from the pump. It consequently cools the air, and that in its turn suffers a further drop, and cools still further the air that is next coming on.

The two factors in this regenerative process are (1st) the interchanger of heat between the going and coming air, and (2nd) the step-down drop in temperature, in consequence of which the air that is going away is always colder than the air that is coming on.

There are two ways in which the step-down or drop in temperature, which is essential to the action, may be produced. One way is to let the air coming under pressure from the pump expand in a cylinder doing work on a piston while its pressure falls. That is the way in which the cooling effect is produced in an ordinary refrigerating machine, using air as its working substance.

As early as 1857 Sir William Siemens proposed to combine a regenerator or heat-interchanger with an expansion cylinder, so that the drop in temperature caused by expansion should be communicated to the incoming air, and thus the working should, as said, "produce an accumulated effect, or indefinite reduction of temperature." And more recently the same idea has taken practical shape in the patents of Solvay and Windhausen, and in the experimental apparatus used in his cryogenic laboratory. Professor Onnes, of Leyden. In all these cases the drop was produced by the use of a cylinder, which allowed the air to do mechanical work as it expanded.*

But there are serious obstacles to an "indefinite reduction of temperature" by such a device; and, in fact, Solvay found that he did not succeed in getting below about -95°C . For one thing, the mechanical difficulty of working a piston at an extremely low temperature is formidable; and further, its friction develops heat just where heat is not wanted, and the bulk of the cylinder necessarily involves a large leakage of heat from outside.

There is, however, another way of producing the necessary drop in temperature, and by using it Professor Linde has made practicable the regenerative method of producing extreme cold. In his apparatus the drop in temperature is effected by letting the compressed air stream through a small orifice, namely, a nearly closed throttle-valve, from a region of high pressure to one of much lower pressure. If air were a perfect gas, in the thermodynamic sense, it would suffer no drop in temperature when it expands in this way without doing work. Indeed Joule in his early experiments on this subject detected no cooling, and it was only in the more delicate investigation which he made later in conjunction with Lord Kelvin, that a small amount of cooling was observed and measured. Kelvin and Joule found that when compressed air expands by passing through a constricted orifice, its temperature falls by about a quarter of a degree for each atmosphere of difference in pressure between the two sides of the orifice. This is at ordinary temperatures; at low temperatures rather more cooling occurs, for the gas is then less nearly "perfect." An effect so small does not at first sight appear promising as a means of reaching extremely low temperatures, but Linde has shown that it is enough to furnish the step-down necessary in a regenerative process. The gas, cooled slightly by passing through the orifice, gives up its cold to gas which is approaching the orifice. The passage through the orifice cools that gas further, and so on, with the result that a cumulative cooling proceeds. When the step-down is effected in so simple a manner, it is comparatively easy to insulate the apparatus, and to reach an extreme of cold greatly lower than could be reached if an expansion cylinder were used. A temperature of -200°C . or lower is attained without difficulty, whereas with an expansion cylinder a practical limit was found at -95°C .

* It should be added that on May 23, 1895, Mr. William Johnson lodged a Provisional Specification for "Improvements relating to the progressive refrigeration of gases," in

which the use of a heat-interchanger is described, but without making it plain in what way the patentee intended to produce the drop in temperature.

Fig. 2 shows the organs of Dr. Linde's apparatus in its simplest form: P is the pump which delivers highly compressed air first to a water cooler, J K L, to remove the heat generated by compression. The compressed air goes on through the inner of two pipes forming the spiral interchanger, D E, and escapes through the throttle-valve, R, into the chamber, T, suffering a drop in temperature. It leaves the chamber at F and returns to the pump through the space between the inner and outer tube of the interchanger, so that the gas coming down inside the inner tube is cooled before it reaches the throttle-valve. In

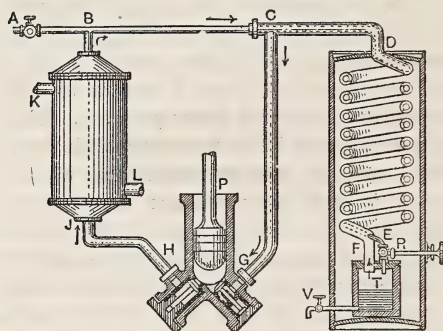


FIG. 2.

his earliest experiment, made in May, 1895, Linde used no preliminary cooling of the air, but succeeded, after 15 hours' continuous working, in getting so great an accumulated cooling effect that liquid air began to gather in the vessel T, from which it could be drawn off by a tap. Any removed in this way, or lost by leakage, is made good by pumping more in through the stop-valve at A, by means of an auxiliary pump.

Another arrangement of the apparatus, designed to yield an atmosphere rich in oxygen, is shown diagrammatically in Fig. 3. There the interchanger is divided into two parts, down which the compressed air streams in parallel through the two inner tubes which converge at A. It goes on through a worm in the receiver, B, to the throttle-valve, C, and is there discharged into the receiver. The gas which is given off from the surface of the liquid in B is mainly nitrogen, and it passes off through one of the two interchangers. The liquid that is left in B becomes rich in oxygen, and is allowed to drain slowly through the valve, D, and then to evaporate through the other interchanger. Thus the gas which passes off at N consists mainly of nitrogen, while the gas that passes off at O consists largely of

oxygen, and forms the useful product of the apparatus. Both gases as they escape through the interchanger give up their cold to the incoming compressed air, and leave the apparatus at a temperature which is only a few degrees lower than that at which the air enters.

In cooling a gas by making it expand through a constricted orifice, the amount by which the temperature drops is proportional to the difference of the pressures p_2 and p_1 on the two sides of the orifices. But the work which the pump has to do in forcing the

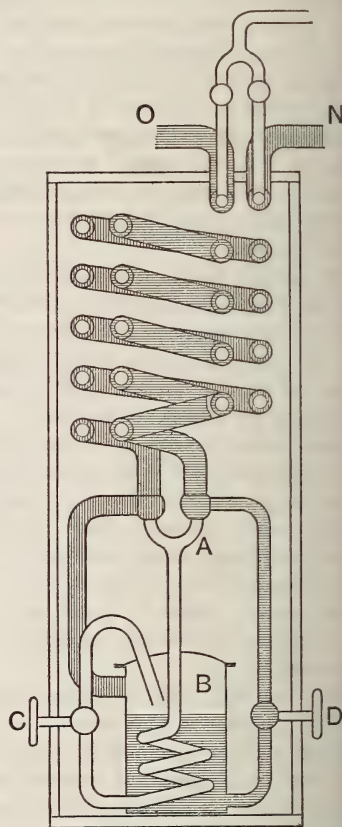


FIG. 3.

to pass again and again round the cycle depends not on the difference but on the ratio of p_2 and p_1 . Hence, to make the system efficient, what is aimed at is a large difference $p_2 - p_1$, but a small ratio $\frac{p_2}{p_1}$. This requires that p_2 should be high, and p_1 moderately high. Dr. Linde accordingly makes the upper limit of pressure, p_2 , about 200 atmospheres, and in some cases he makes the pressure on the other side of the orifice as much as 150 atmospheres. Thus a drop of 150 atmospheres

is then associated with the very moderate value of four for the ratio of p_2 to p_1 . On the other hand, if in passing the orifice the pressure of the gas were allowed to fall to that of the atmosphere, the drop on which the cooling effect depends would be increased from 150 to 199, but the ratio on which the work depends would be increased to 200. The cooling effect would be only one-third greater, whereas the work to be done by the pump, which varies as the logarithm of this ratio, would be nearly four times as great in the second case as in the first. The efficiency of the process is therefore nearly three times greater in the first case.

liquefied; the greater part returns to the pump to be compressed and sent through the orifice again. Hence it is important to maintain a comparatively high back pressure, p_1 , for the greater part of the gas, and only to allow the portion that is to be withdrawn from the apparatus to fall to atmospheric pressure. This is done in Dr. Linde's newest apparatus, in the manner shown in Fig. 4, which illustrates the laboratory form now exhibited in action.

There are two throttle-valves, a and b . All the compressed air passes through a , but only a small proportion (about one-fifth) passes also through b . The passage through a causes a drop in pressure from 200 atmospheres to 16

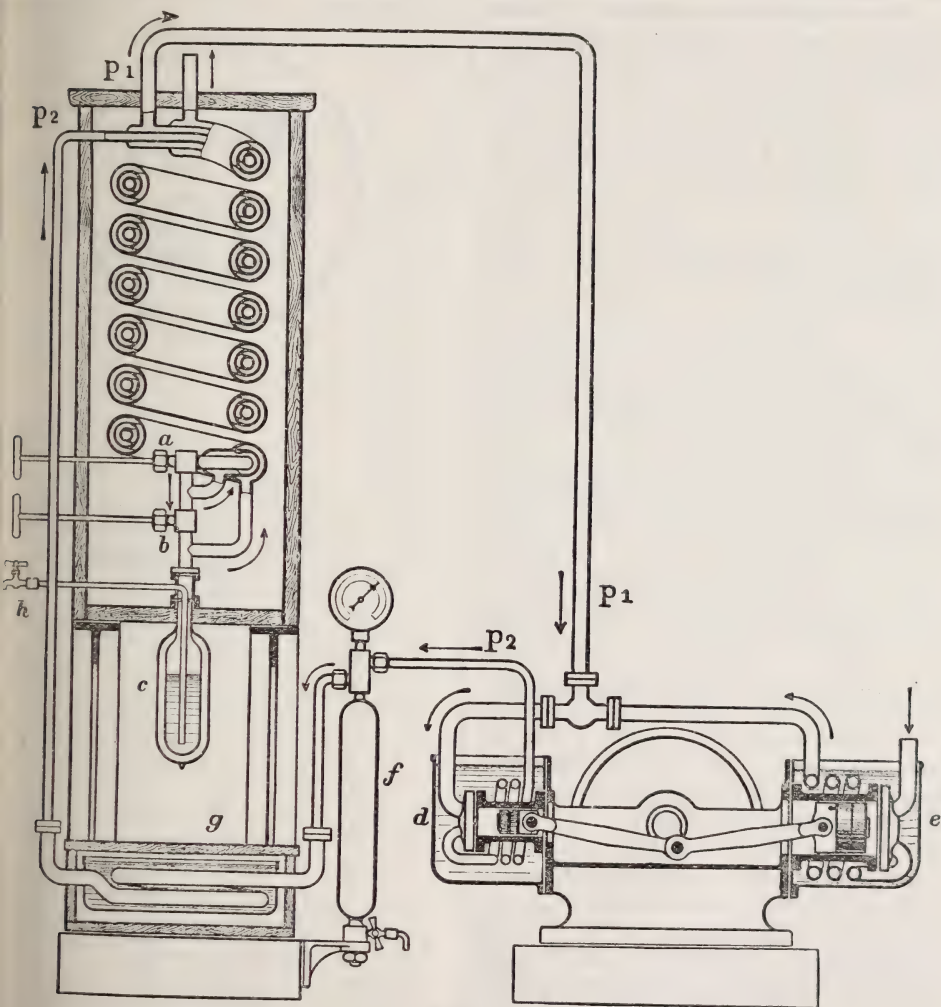


FIG. 4.

Even after the apparatus has become fully cooled down, and has attained a uniform temperature in its working, only a small portion of the air that passes through the orifice is

liquefied, and four-fifths of the air in circulation passes back at that pressure through the middle one of the three tubes composing the interchanger to the pump d . The remain-

ing fifth passes through *b*, and about one-fourth of it gathers as liquid in the vacuum-jacketted vessel *c*, at a pressure which is only so much above that of the atmosphere as will allow the liquid to pass out when the stop-cock *h* is opened. The unliquefied or re-vaporated part of what has passed through *b* escapes through the outermost tube of the interchanger. The pump *e* takes in fresh air from the atmosphere, compresses it to 16 atmospheres' pressure, and delivers it so that it mixes with the air which is returning at that pressure from the middle tube of the interchanger to the pump *d*. The compressed air, on leaving each pump, passes through a coil in a water-cooler which also serves to jacket the pump. A small quantity of water is drawn in along with the air by the low-pressure pump, and this, together with the natural moisture of the air, is extracted as completely as possible, first by means of a separator *f*, and then by making the compressed air pass through a coil *g* in a bath of ice and salt before it goes into the interchanger. The interchanger is enclosed in a case packed with sheep's wool.

The admirable device of the open vacuum-jacketted vessel, which we owe to Professor Dewar, enables liquid air to be decanted and handled with the greatest ease, to be conveyed from place to place, and to be stored during short periods with no more than a very moderate loss of evaporation.

The machine now exhibited circulates about 15 cubic metres of air per hour in the circuit from 200 atmospheres to 16 atmospheres. About three cubic metres per hour are pumped in from outside, and this is the amount which passes through the lower valve. I am informed by Dr. F. Linde that about 0.9 litres of liquid air are formed per hour, with a continuous expenditure of three horse-power. Larger sizes of the machine are made, requiring five and seven horse-power respectively. More than a dozen of these machines are now in use in various Continental laboratories.

Dr. Linde is now constructing a machine of 120 horse-power for the Rhenania Chemical Works at Aix-la-Chapelle, which is to be applied to the improvement of the Deacon process of chlorine manufacture. This machine is expected to produce 50 litres of liquid air per hour, or in round numbers 1 lb. of liquid air per horse-power hour. In the Deacon process, as ordinarily carried out, a mixture of hydrochloric acid with air is treated, and a mixture of chlorine with nitrogen is produced. Dr. Linde's machine will serve two purposes,

namely, (1) to increase the efficiency of process by substituting a gas rich in oxygen for atmospheric air in the first instance, (2) after the treatment, to cause the chlorine to be separated as a liquid from the mixture product without compression, through the agency of cold. In this case the interchanger takes the form of one great spiral made of an outer tube 100 millimetres in diameter with an inner tube 60 mm. in diameter and $4\frac{1}{2}$ mm. thick to convey back the air at (which is 50 atmospheres), and inside of these are four tubes, each 12 mm. in diameter and 3 mm. thick for the high pressure air at 200 atmospheres (see Fig. 5). The tubes are all of copper.

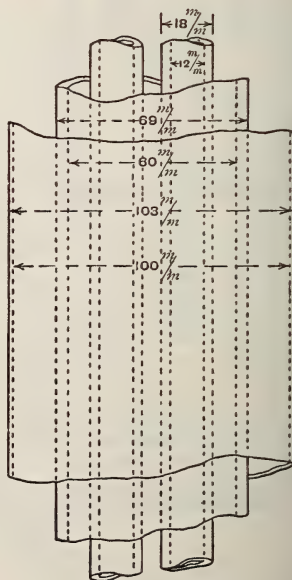
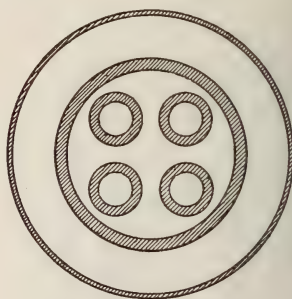


FIG. 5.

Various further uses for the richly oxygenated atmosphere in metallurgical and other processes are under consideration. Furnaces and bl

pes in which combustion is sustained by the enriched air may be expected to find application for many purposes. Suggestions for other uses have been made, but have not yet gone far enough to be referred to in detail.

The most interesting application of the liquid which has hitherto been tried on a commercial scale is to make an explosive by mixing it with carbon. When liquid air, enriched by the evaporation of a large part of its nitrogen, is mixed with powdered charcoal, it forms an explosive comparable in power to dynamite, and which, like dynamite, can be made to go off violently by using a detonator. To make the explosive, Dr. Linde pours the liquid, containing about 40 or 50 per cent. of oxygen, on fragments of wood charcoal, two to four cubic centimetres in size. These are kept from clattering under the ebullition of the liquid by mixing them into a sort of sponge with about one-third of their weight of cotton wool. The liquid which remains is, of course, richer in oxygen than that which is originally applied, and when the mixture is allowed to stand for long all the liquid evaporates and the explosive power disappears. It must, therefore, be mixed just before or near the place where it is to be used. To the cotton wadding impregnated with the charcoal powder can take up more than enough of the liquid to supply oxygen for its complete combustion, and when put quickly into thick insulating cases, made of paper, it retains its full explosive power for five or ten minutes. After an interval, which ranges from fifteen to thirty minutes according to the size of the cartridge, all explosive power is lost. Experiments with the explosive were made on the Parade-ground at Munich, and a practical trial on a large scale has gone on for some months in a coal mine at Penzberg, not far from Munich. The trials there were continued from July to October of last year, and are deemed to have given very satisfactory results. The chief advantage of the explosive is its cheapness, the cost being to all intents and purposes simply that of the power used in liquefying the air. Even the fact that after a short time the mixture ceases to be capable of exploding may be urged as a recommendation in one respect, for if a detonator hangs there is no danger of the charge going off accidentally some time after the explosion is over; nor is there any risk of its being purloined or used for criminal purposes. On the other hand, it is obvious that this explosive would be neither convenient nor economical, and is not in cases where a large amount of

blasting is to be done at or about one place, and during a long period of time. A great stone-quarry or slate-quarry, or an engineering work such as the cutting of an Alpine tunnel, would appear to offer a likely field for its application.

In the trials made at Pensberg the machine used was of the type now exhibited and shown in Fig. 4, but large enough to produce 3 litres of the liquid per hour. The liquid as withdrawn from such a machine contains from 35 to 40 per cent. of oxygen, and is sufficiently rich to be used for making the explosive, with no more than the further strengthening which it necessarily gets through evaporation in the processes of transport and mixing.

By using a liquid containing more or less nitrogen in the filling of the cartridges the strength of the explosion is under some control, and it is suggested that the temperature may in this way be kept down sufficiently to minimise the risk of igniting fire-damp and coal dust in mines.

With a machine in constant use Dr. Linde obtains from 0.4 to 0.5 litres of a liquid containing 50 per cent. of oxygen per horse-power hour. If we assume that up to the instant of explosion two-thirds of the liquid has been evaporated, which raises the proportion of oxygen to 80 per cent., then 4 to 5 horse-power hours are used in producing 1 kilogramme of explosive material. Beyond this there is the cost of the wrapping, the cotton wool, and the charcoal powder. But these items are inconsiderable.

DISCUSSION.

Mr. ADAIR asked if liquid air froze at such a low temperature.

Mr. R. N. LENNOX said he must express his admiration of the very clear way in which Professor Ewing had explained the subject, and also of the very beautiful apparatus downstairs, but personally he did not think it had any extraordinary efficiency. He had used an apparatus of the same type, of 3 horse-power, which gave practically one litre per hour by the cascade system, which he thought more effective and convenient. Of course, Dr. Linde only used two pumps, while the cascade system required three.

Professor EWING said liquid air could be frozen, but it did not freeze of itself by evaporation under ordinary atmospheric conditions. He should like to know if in the system Mr. Lennox referred to there was a high back pressure.

Mr. LENNOX said no; the forward pressure was 300 atmospheres, and there was no back pressure.

Professor EWING said he had endeavoured to point out the great advantage of expanding with a comparatively high back pressure, which made the whole system much more economical.

Mr. BLOXAM asked for further information with regard to the cooler, which he understood was for the purpose of abstracting the heat from the compressed air. It seemed to him that after a time the compressed air would get so cold that the cooler would not take heat from it, but rather tend to warm it.

Professor EWING said that the air in the pump did not become cold at any stage in the process. The interchanger was formed on a much longer coil of pipes than appeared by the diagram, giving a very extended surface for the communication of heat between the gas coming away cold and that going forward to pass through the orifice. Even after it had been at work a long time, and had attained a uniform regime, when there was an extremely low temperature at the nozzle, if the temperature were examined at various points of the spiral, it would be found that there was a gradient going up to nearly the atmospheric temperature at the top, there being a continual interchange of heat all the way between the air in the interior tube and that in the one surrounding it. To make the interchanger efficient it was necessary that there should be only a slight difference of temperature at any given point between the air in the inner and outer tubes. When the air escaped at the top of the interchanger, it had given up nearly all its cold to the air inside, and had risen nearly to atmospheric temperature. The pump was, therefore, practically working on air at ordinary temperature the whole time, and the air was kept cool in the process of compression partly by the water jacket, and partly by injecting a certain amount of water into it, which was afterwards extracted by means of a separator. Any residue of water vapour not extracted in this way was deposited in a coil, placed in a bath of ice and snow. It was absolutely necessary that this cooling operation in the vessel J should go on continuously.

Mr. WALTER MAY asked if the water introduced into the air did not form snow, and if so how was it got rid of?

Professor EWING said if the water were allowed to remain in the air until it reached the interchanger it would of course freeze, but it was extracted, as he had just explained, before it reached that point.

Mr. K. B. DOYLE asked what became of the carbon dioxide in the air used?

Professor EWING said it was either deposited with the water in the separator, or was frozen in the interchanger. At any rate, it did not cause any inconvenience.

Colonel ALLAN CUNNINGHAM asked if the explosive mixture was made in the open air with the hand, and if it was at all dangerous to handle or to cause frost-bite. Also if it had to be protected in any way while being carried about. He also asked if there was not a great rise in temperature when the explosion took place. It was stated that the temperature of explosion was so low that it would not ignite firedamp.

Professor EWING said it was put into cartridges and was left open to evaporate at the surface, otherwise it would immediately develop a pressure which no cartridge would stand. He had not seen the process of mixing, and could not give any details with regard to it. With regard to the temperature, of course there was a rise of temperature when the explosion took place, but it was claimed that that was to some extent controllable by the amount of nitrogen allowed to be present in the liquid.

Mr. W. H. RICHARDSON asked if this explosive had been practically used in mining?

Professor EWING said so far the use of this explosive had only been experimental, though the experiments had been made on a commercial scale. It was used for some months in a coal mine at Penzance in order to try whether it could be employed successfully, and so far it was successful; but it was not adapted for use in coal mines, where the explosion had to be performed in places which were not so open together.

The CHAIRMAN, in proposing a vote of thanks to Professor Ewing, said there were many points connected with this work of Dr. Linde's on which might enlarge if time permitted. The mechanical ingenuity and knowledge of thermodynamics which Dr. Linde had displayed were worthy of all praise. After some fourteen years' work he (the Chairman) ought to know something about low temperature, but he must confess that the practicability of a mode of working had never struck him. It was, however, a mistake to suppose that in order to produce liquid air or oxygen it was necessary to use liquid ethylene. In an early paper, in 1881, he showed that it was easy to get liquid oxygen by the use of a little solid carbonic acid. By the use of a vacuum pump one could reduce the temperature to about 100° C., and there the critical point of oxygen was approached, and by expansion the oxygen was easily produced. The same process occurred with air, only a little higher pressure had to be used in order to produce sufficient expansion. By the use of nitrous oxide, a liquid largely

temperature of -120° C. can be reached, and compression and expansion, one can from that easily obtain liquid air. But the yield was not at when this method was used on the large scale, and consequently one naturally applied the factors which Dr. Linde had made so paramount and clear in the use of ammonia in making a liquid that had a low boiling point and a high latent heat. That was where the advantage of liquid ethylene came in, but it was not essential. Again, although this regenerative system had been used by Dr. Linde to the acme of perfection, no one constructed low temperature apparatus rejected cool gas without utilising it; the great advance was that Dr. Linde did so completely. In using ethylene, for instance, the ethylene had to be compressed, and that involved a large amount of evaporation. It had to be discharged into a hot vessel, because -80° C. was hot to a liquid coming into it at -100° C. The ethylene therefore boiled off, and the cool ethylene vapour was used to pass round the outside of the pipes, which were delivering the gaseous ethylene before its expansion. Both Ohnes and himself, therefore, used, or economised, the temperature of the expanding gas in order to cool the gas going forward; but Dr. Linde was entitled to every credit for elaborating a machine in which this was done as perfectly as possible. He was glad to find that in many respects Dr. Linde corroborated the results which he had described from time to time. In regard to the per-centage of oxygen in the liquefied air, if really pure liquid air was wanted, the temperature of the vessel must be lowered to about -100° C, in order that it might liquefy at the pressure of the atmosphere, and that nothing should escape; the results of working a small apparatus with vacuum tubes in the laboratory resulted practically in liquid air which contained about 50 per cent. of oxygen. A more interesting point was that of the efficiency of the machine, which was rather for an engineer than a chemist to deal with; but what he attributed to the Chemical Society was that in using direct air obtained by continuous adiabatic expansion, which this was practically, a yield of about 10 per cent. by weight. If one compressed to 200 atmospheres and then expanded from a pin hole at the end of a short length of pipe, about 5 per cent. of the air could be collected. This was just what Professor Ewing had given as the result of the process, and the thermodynamic efficiency seems to have substantially the same value. In order to collect a small quantity of liquid air, all that was needed was to buy a bottle of compressed air at 200 atmospheres, take a small coil of copper pipe and put it into a vacuum vessel. By the use of solid carbonic acid it could be cooled to -80° ; then expanding through a small coil with a pin nozzle, 80 c.c. of liquid air could easily be collected in twelve minutes, after the nozzle had got cold in half that time. It could go on collecting from every 25 feet that you passed practically the same amount. The result

was a yield of 0.9 litre per hour was obtained. It was very satisfactory to him to find that at any rate he had contributed something to this ingenious apparatus, viz., the use of vacuum vessels. Of course, it would be almost impossible to utilise a small yield of liquid air unless it could be isolated from heat sufficiently to prevent a large loss. If only 15 c.c. a minute were produced, there would not be more than one-fifth of that left if a vacuum vessel was not used. Even using three successive screens of air, so as to greatly diminish the access of heat, it would not be diminished to more than one-third; but by using a vacuum vessel the loss was at once reduced to one-fifth of what it was originally; and this could be much improved by silvering the vacuum vessel on the interior. Then, instead of the influx of heat being reduced to one-fifth, it was brought down to 1-33rd, so that only 3 per cent. of the exterior heat could get in. Where the object was to collect liquid air in quantity over a long period, isolation from heat was the chief element of success. The most convenient method probably was to use a mercury vacuum, which was very readily effected in the laboratory. There was a Torricellian vacuum with nothing but the vapour of mercury left in it, and directly the liquid air was collected in the inner vessel, the mercury vapour coated it beautifully on the outside. He was very pleased to see that the use of these vacuum vessels was extending. Not long ago, it was said on the continent that they were of no use, because it had been proved that at such low temperatures everything was transparent to radiant heat; whilst other scientific gentlemen had used them without acknowledgment. He was surprised that Dr. Linde had not employed isolation for his cooling coils, but, no doubt, many further improvements would be made, and he should imagine that if the interchanger were surrounded by a vacuum vessel it would be rendered far more efficient, as the influx of heat would be completely stopped, the result would probably be that the liquefaction of the air would begin in a few minutes instead of taking two hours. He must also congratulate Dr. Linde on the practical applications he was making of liquid air. The suggestion for improving the chlorine manufacture was highly ingenious, and the application of it to explosives seemed almost to invert the order of nature, because all chemical action at these low temperatures was practically annihilated. You could not get substances to react by mere contact. The only action that went on so far as he was aware was photographic action, and this might be due to the secondary effect of the phosphorescence which was a very marked phenomenon at low temperature. There was no electric action and no chemical action at these low temperatures. To produce a chemical reaction you must have a high initial temperature. You could burn hydrogen below the surface of liquid air and you could burn a diamond or graphite on the surface of liquid oxygen. Ordinary cotton wool sponge produced an explosive mixture

and so did charcoal in powder. He was delighted to find that anyone was bold enough to suggest that this would make a practical explosive and he wished it every success. There was no more explosive substance at these low temperatures than ozone, which had a deep blue colour when liquefied. There was room for any amount of experiment there, but he could not get Mr. Lennox to look at it, and he had a colleague at Cambridge who after experimenting with liquid ozone went off and never came back to repeat the experiment. It would detonate by the mere action of light, like fulminating mercury. Somewhat similar was nitric oxide, a most permanent gas, the nearest to carbonic oxide. When liquefied it produced a nice slightly blue liquid. As it had a strong affinity for oxygen, producing ruddy fumes in air, he thought he would try the reaction at low temperatures, and that it would probably yield a solid nitrous acid. Mr. Lennox suggested that they should break a tube in which they had some liquid nitric oxide in liquid oxygen, and both substances remained apparently quite unaffected, but on lifting the tube as soon as it reached the surface, they saw no more of it, glass nor anything else. No doubt the slightest increment of temperature was sufficient to start it, and the whole thing went off instantaneously. There was an almost infinite field open for research in the region of low temperatures, and he thought Dr. Linde was mainly to be thanked for having enabled the cryogenic laboratory to be widely disseminated. In the interests of science, it was not desirable that any particular line of research should be permanently confined to one or two places. It was much better when the pioneers had had the satisfaction of showing the way, that investigators all over the world should be enabled to pursue the subject, and from this point of view Dr. Linde had rendered infinite service. He had recently received most extraordinary accounts of experiments on liquid air in America, some of which seemed to belong rather to the domain of faith than science, but at any rate they showed the wide interest which was being taken in this field of research. They had been some 300 years learning the properties of matter and the forms of energy at ordinary temperatures, say within the limited range of about $+300^{\circ}$ absolute temperature, and one might well ask how many years were required to examine them at temperatures like -200° or 74° absolute. Even with all their present advantages it would not be too much to say that there was plenty of work for everybody who would undertake it for the next fifty years. In that view, everybody would be pleased to see the apparatus of Dr. Linde widely distributed, and no one could be more delighted than he was at its success.

Dr. W. HAMPSON asked to be allowed to say a few words in consequence of what had fallen from the Chairman. He had expressed the hope that Dr. Linde might so perfect his apparatus as to be able

to produce liquid air in a few minutes instead of hours, and he wished to say that this had already been done, and anybody could see the apparatus at work at Brin's oxygen works, Westminster. In the *Engineer* for November 20, 1896, Dr. Linde described his apparatus, and then expressed the view that instead of pipes concentrically arranged one within the other, only one pipe was used, and the expanded air were allowed to return at atmospheric pressure in an outer jacket, the weight of the material employed might be much reduced. At that time he (Dr. Hampson) had already constructed an apparatus on that principle; the weight of his interchanger being $14\frac{1}{2}$ lbs., as against $13\frac{1}{2}$ lbs. for Dr. Linde's. In consequence of a better arrangement of the coils the time required to get liquid air was only 16 minutes as against 2 hours. The quantity obtained per hour was in Dr. Linde's, '9 litre, in his, $1\frac{1}{2}$ litre. The quantity of air passing, per hour, in Dr. Linde's was 22 cubic metres; in his, $16\frac{1}{2}$ cubic metres, amount of compression in Linde's 190 atmospheres, in his, 120. If he used a pressure of 130 atmospheres, liquid air could be obtained in 10 minutes, and the air were first cooled by carbonic acid, in one minute. In Professor Ewing's "Howard lectures," last year he had referred to his apparatus, and said how he was informed that the liquid air began to appear after three-quarters of an hour, but that was a mistake. The time he then named was 33 minutes, and that was the first time the apparatus was used, and he himself was away. He might add that 6 per cent. of the air passing was liquefied. He thanked Professor Ewing for the great fairness with which in those lectures he treated the various workers on this subject.

The vote of thanks having been passed,

Professor EWING, in reply, said it was a great pleasure to him that the chair was occupied on this occasion by the greatest living authority on liquid air, and on low temperature research generally, and his remarks formed the most valuable part of the discussion. What Dr. Hampson had said was also of great interest. He understood him to imply that he used an expansion nozzle, in conjunction with an interchanger, substantially in the same way as Dr. Linde. He was sorry that there should have been any slip in anything he said in the Howard lectures, either about Dr. Hampson's apparatus or anything else, as he had done his best to do justice to all who had worked on the subject. When he referred to the use of ethylene as being the most practical mode of producing liquid air in considerable quantity, he did not forget the experimental method in which small quantities had been produced by the Chairman and others without the use of ethylene, and in the Howard lectures he had described other methods, but on the present occasion there was time to go over all that ground again. He believed it was correct, and Professor Dewar would

out, that until Dr. Linde's process was established the only practical mode of liquefying in considerable quantities was by the use of ethylene. It was quite true that the figures gave worked out to about 5 per cent. of air compressed, which was the same as was obtained in a very simple form of apparatus, but the work done by the pump was about four times as much in one case as in the other. If you expanded air from a pressure of 200 atmospheres to 50, you were doing only one-fourth the work which was required if it was expanded to atmospheric pressure. You might get the work done for you by getting an oxygen bottle, but it had to be pumped somewhere; when it came to working on a large scale you had to consider the whole work done by the pump. Though in the apparatus exhibited a plain vacuum vessel was used, he believed Dr. Linde did take advantage of the Chairman's discovery of the importance of silvering. Dr. Linde did isolate his heating coil by packing it with a very non-conducting material, namely, raw sheep's wool, and that was an important factor in determining the efficiency of the apparatus. The period which elapsed between putting the apparatus and the first production of liquid air was determined, not merely by the leakage of heat, but by the thermal capacity of the apparatus itself, and isolation by a vacuum vessel, if it could be carried out conveniently, would not affect the second factor. One of the things Dr. Linde had in his mind was the production of ozone, though he did not intend to use it for blowing up his assistants for anything else, but for hygienic purposes. The suggestion, and several others, were as yet only in the air, but possibly something would be heard of in the future.

Miscellaneous.

THE SALT WELLS OF CHINA.

One of the most interesting industries of China is connected with the salt wells, and it is this industry which evidences Chinese ingenuity more clearly than any other. The building of the great wall required little engineering skill, and the Grand Canal is only the connecting link between the natural waterways of China, a proof of industry rather than ingenuity; but the ingenuity which seventeen hundred years ago bored through solid rock to the depth of from 2,000 to 5,000 feet attests scientific skill which may still interest. The salt wells of China are found in Szechuen, Yunnan, Shansi; but the more important are near the mouth of Tze-lin-tsing, in the province of Szechuen, about 175 miles west of Chungking, and an equal distance south-east of Chengtu. The salt belt is a regular tract having the Min River, from Chingtu to its junction with the Yangtze at Suifu, for

its base, and its apex near Tze-lin-tsing, an area of some 1,500 miles. The number of wells in this region officially reported are twelve hundred, but the number is larger, and by some is estimated at five thousand. They average about 6 inches in diameter and vary in depth from 700 to 5,000 feet, though there is one well reported to be 5,900 feet deep. According to the United States Consul-General at Shanghai the boring is done by means of a wrought-iron rod, about 14 feet in length, with a steel edge which forms the chisel for drilling, and other rods are joined by bamboo fastenings as the depth increases, the whole being worked up and down by a lever raised by a number of men jumping on one end and lowered by being set free, the process being aided by a counterbalancing weight attached to the other arm of the lever which is increased as the rods are increased in number. As the rod is raised and lowered it is turned first one way and then the other by a man placed in charge of it. In this manner it generally requires from thirty to forty years to bore a well of medium depth. When the boring begins, it is not known whether salt or gas will be found, but as both are very valuable it is not a matter of much consequence. The brine is lifted from the wells in long bamboo tubes or buckets with a leather valve in the bottom, and this is drawn up by a bamboo rope which passes over a pulley fixed in the top of a lofty derrick from 60 to 70 feet in height. The rope wears out rapidly and must be replaced about once in ten days. The bamboo bucket is not more than 3 inches in diameter, but may be 60 or 100 feet in length, proportioned to the height of the derrick, and thus some 200 catties (266 pounds) of brine is brought up at each turn. The rope passes down from the pulley and under another wheel fixed but a few feet above the ground and thence into a shed where it is wound round a large drum turned by three or four water buffaloes. It takes from fifteen to twenty minutes to draw up a bucket from the deeper wells, and when it is swung up under the derrick, a workman pushes an iron rod into the bottom and lifts the valve, allowing the brine to escape into a tube, whence it flows into a large reservoir that is kept under lock and key. The brine is not all of equal value; the deeper the well the stronger the brine. The best has a blackish dirty appearance, and both the gas and brine wells give off a very disagreeable odour, due perhaps to the presence of carbonated hydrogen gas. The buffaloes are kept in excellent condition, and they are allowed a respite after drawing up two loads, and each animal is used four or five times during the twenty-four hours. They do not, however, long endure the strain, and few last longer than five years, some not longer than one year. This is owing to the fact that they are slow beasts, and cannot accustom themselves to the rapid gallop at which they are driven while drawing up the brine. From the reservoir this brine is conducted in bamboo pipes to the evaporating sheds. It flows first into casks,

whence by smaller pipes it is conducted to the pans. The pans are quite shallow, and measure from four to six feet in diameter, and weigh as much as 1,600 pounds. These are not generally property of the salt factories, but are leased from the manufacturers. The pans are made in Kiang Tsing, a city on the Yangtze Kiang, not far from Chungking, which seems to be the nearest point at which iron can be obtained, and are conveyed to within a short distance of the wells. Each pan is swung from a heavy beam, requiring the strength of sixteen men to carry it from boat to boat. The gas wells are not so numerous as the brine wells, nor do they usually belong to the same proprietors. Some maintain that the product is petroleum gas; others that it is the production of the brine wells; that when they are first opened the gas rushes out with tremendous force, and must be consumed before the wells can be worked for salt. The gas is in great demand for use as fuel. The salt is of too kinds, pan or lump salt, and granular. The former has the shape of the pan; the latter has bean flour added to it to increase its whiteness. There are about forty districts in Szechuen in which salt is manufactured, but the annual production of that province is difficult to determine, but is said not to be less than 300,000,000 lbs. The sale of salt in China is a Government monopoly. From the one province of Szechuen alone a revenue of £500,000 is obtained. The price of salt at the wells is about $\frac{3}{4}$ d. per lb., but to this must be added the Government tax, which at the wells is about a $\frac{3}{4}$ d. per lb., making a total of 1d. The price, however, increases with the distance from the wells, owing to the numerous *likin* stations which must be passed, a tax being levied at every station. Well salt is also produced in Yunnan, Kansuh, and Shansi. In the Eastern provinces it is obtained at a much cheaper rate by evaporation from sea-water. On the coast of Chihli wind-mills are found, slowly revolving about a perpendicular axis, pumping water into vats. The sale of salt is regulated by licenses, and a license once issued is good for ever. It is used year after year, and handed down from father to son, though it may be transferred to others if desired. The whole Empire is divided into seven circuits for purposes of salt administration, and the source of supply for each circuit is strictly limited, and any salt coming in from other quarters is regarded as smuggled, and is confiscated. The entire revenue derived from salt by the Chinese Government is estimated at £2,185,000. Since the war with Japan the Government has increased the salt tax. The annual consumption for all China is estimated at over 3,300,000,000 pounds. The importation of foreign salt is altogether prohibited. At one period salt was used as money in China. The salt was formed into cakes, which could not be prepared by any other than the officers of the Emperor, and the cakes were impressed with his stamp. The cakes were valued at twopence each, eighty cakes being equal in value to about the sixth part of an ounce, and consequently a cake of salt was

in value the one hundred and eightieth part of an ounce of gold, which, at the price of £4, is equal to twopence for the price of each cake.

PARA AND AMAZONIAN RUBBER

It is stated in a Foreign Office report from the Majesty's Consul at Pará that the total amount of Amazonian rubber exported from Pará, Mato Grosso, Bolivia, and Peru during the twelve months ending June 30, 1897, was 22,216 tons, of which 12,368 tons were sent to Europe, and 9,848 to the United States. The Amazonian crop during the same period amounted to 22,315 tons, of which 9,100 tons belonged to the State of Pará. The amount of Amazonian rubber exported during the year ending Dec. 31, 1896, was 21,597 tons, of which 12,542 tons were sent to Europe (10,637 to the United Kingdom and 1,905 to France), and 9,055 to the United States; while the amount of Amazonian rubber exported in 1897 (Jan. 1 to Dec. 15) was 20,554 tons, of which only 9,726 tons went to Europe, and 10,828 tons to the United States.

The value of the rubber exports from Pará during the year 1896-97 was £1,977,596, and the duties collected on this value amounted to £415,295.

All the trade between the States watered by the Amazon (*i.e.*, Pará, Amazonas, Peru, and Bolivia) and the United States is transported in British bottoms; and all the rubber purchased by the United States is paid for through British banks, in which there are three established in Pará. A British company—the Amazon Steam Navigation Company of London—possess 35 steamers for the navigation of the river Amazon. Over 100 river steamers belong to Pará. Most of them were made in England, and merchants in Pará, Manáos, and Iquitos are continually purchasing others from the same source. Purchases have been made also in the United States, France, and Germany, but the British article is found to be superior.

Rubber of the best quality is produced throughout the continent watered by the Amazon between the Andes mountains of Peru, and the maritime authorities on the subject are of opinion that there is absolutely no fear for the exhaustion of the supply of rubber in the Amazonian States. Distance and rapids are not insurmountable obstacles, for in many cases this produce is transported as much as 100 miles before it reaches Pará; and, when rapids impede the way, canoes and their cargoes are hoisted over the water and rolled along the banks, sometimes for several miles, until navigable water is reached. This causes much delay and adds expense, but it is found in the end that distance and prolonged transportation have improved the rubber, so that when it arrives at its destination it sells for higher prices than when collected nearer the mouth of the river.

Notes on Books.

THE YEAR BOOK OF BRITISH COLUMBIA. By R. J. Gosnell, Librarian, Legislative Assembly, and Secretary, Bureau Statistics. Victoria, B.C. 1897. The Year Book of British Columbia for 1897, which has just been issued, has a special chapter on Canadian Yukon, giving a very full account of the country, and ample information as to methods of mining the goldfields, outfit, &c. There is also a detailed map of the district on a large scale. In addition to this, the book contains the usual information about the other parts of the colony.

INTRODUCTION TO COUNTING-HOUSE AND EXAMINATION BOOK-KEEPING: with Examination Papers and an Appendix on Government Book-keeping. By John Dalziel Maclean. London. 1892. Key, 1892.

BOOK-KEEPING AS A SPECIFIC SUBJECT IN STAGES 1, 2, and 3: with numerous exercises to suit the requirements of the graduated course approved by the Education Department. By J. D. Maclean. London. 1897.

The author points out that Business Book-keeping and Examination Book-keeping are very different in scope and aims, and in the first-named work he sets out a set of transactions from the business books of a firm so that the learner may gain a knowledge of the practice of book-keeping as well as of the theory. Specimens of papers selected from Civil Service, City of Arts, Scotch Leaving Certificate, and University Examinations in Book-keeping are added and several modes of solution are given.

Part I. of the second work the pupil is shown the simplest commercial transactions are recorded and taught the use of the day or sales-book, cash-book, journal and ledger. In Part II. the pupil is introduced to some of the more complicated forms of business transactions and taught the use of the cash-book, day-book, and invoice-book as actual business. In the third part the practice of counting-house book-keeping is explained, and the pupil is introduced to the form and use of a warehouse-book. The whole is intended as an introduction to the higher forms of Book-keeping and Account-

sailing vessels of 22,404 tons as compared with the similar figures for 1896. 98.5 per cent. of the tonnage classed has been built of steel; and about 1.2 per cent. of iron. Sailing tonnage, which formed 25 per cent. of the total tonnage classed in 1891, 30 per cent. in 1892, and 18 per cent. in 1893, forms less than 6 per cent. of the present total, notwithstanding the large sailing tonnage built in France under the supervision of Lloyd's Register.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock:—

MARCH 16.—“The Recent History of Paper-making.” By CLAYTON BEADLE.

MARCH 23.—“The Preparation of Meat Extracts.” By C. R. VALENTINE.

MARCH 30.—“Telegraphy Across Space.” By Professor SILVANUS P. THOMPSON, F.R.S. J. W. SWAN, F.R.S., will preside.

Dates to be hereafter announced:—

“Stage Mechanism.” By EDWIN O. SACHS.

“Water Gas and its Applications.” By Professor VIVIAN LEWES.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock:—

MARCH 31.—“The Earthquake in Assam.” By HENRY LUTTMAN-JOHNSON, I.C.S. The Right Hon. Sir HENRY FOWLER, G.C.S.I., M.P., will preside.

APRIL 21.—“Recent Railway Policy in India.” By HORACE BELL, M.Inst. C.E.

APRIL 28.—“India and Currency.” By Sir EDWARD SASSOON, Bart.

MAY 19.—“Chartered Companies and Colonisation.” By Sir ALFRED COMYNS LYALL, G.C.I.E., K.C.B., D.C.L. (Member of the Council of India).

The meeting of March 31 will be held at the Imperial Institute; those of April 21, April 28, and May 19 at the Society of Arts.

FOREIGN AND COLONIAL SECTION.

Tuesday Afternoons, at 4.30 o'clock:—

MARCH 15.—“The West Indies and Sugar Bounties.” By NEVILLE LUBBOCK.

Date to be hereafter announced:—

“The African: what he is, and what he is capable of becoming.” By the Rev. GODFREY DALE (Universities Mission to Central Africa).

APPLIED ART SECTION.

Tuesday Evenings, at Eight o'clock:—

MARCH 29.—“English Art in Illuminated MSS.” By Sir EDWARD MAUNDE THOMPSON, K.C.B. Sir JOHN EVANS, K.C.B., D.C.L., Treas. R.S., will preside.

General Notes.

BRITISH SHIPPING, 1897.—During 1897, 495 new vessels of 775,144 tons, have been classed by Lloyd's Register. Of these vessels, 450 of 730,166 tons are steamers, and 45 of 44,978 tons are sailing vessels. Corresponding roughly with the general movement of the shipbuilding industry, the present return shows an increase of 48 steamers of 123,413 tons and 15

APRIL 26.—"The Importance of Craftmanship."
By Sir WILLIAM BLAKE RICHMOND, R.A., K.C.B.
MAY 10.—"The Art of William Morris." By F.
S. ELLIS.

MAY 17.—"Practical Points in Italian Majolica
Painting." By WILLIAM BURTON, F.C.S.

CANTOR LECTURES.

Monday Evenings, at Eight o'clock:—

PROF. W. NOEL HARTLEY, F.R.S., "The
Thermo-Chemistry of the Bessemer Process."
Three Lectures.

LECTURE I.—MARCH 14.

Introduction and historical notes—The description
and chemical technology of the process—Plant used
—Modified forms of converters—Fixed and moveable
vessels—Side-blown and bottom-blown charges—
Recent modifications, as the Robert, Tropenas, and
Walrand-Légénis processes—Evolution of heat
during the "blow."

LECTURE II.—MARCH 21.

The course of chemical change in the "blow"—
Thermo-chemical data—Thermo-chemical data in their
application to metallurgical operations—Assumed com-
position of pig-iron—Calculations applied to the
"acid" and the "basic" processes—Other calcula-
tions—Temperature of the metal—The study of the
Bessemer flame and its spectrum.

LECTURE III.—MARCH 28.

The "acid" process—Variations in the flame and
spectrum during the different periods of the "blow"
—Variations in temperature during successive intervals
in the "boil" and "fining" stages—The "basic"
process—Differences in the flame and the spectrum—
Marked difference in the flame of the "over-blow"—
Substances discovered in the flame traced from the
basic charge to the ore.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 14 ... SOCIETY OF ARTS, John-street,
Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof.
W. N. Hartley, "The Thermo-Chemistry of the
Bessemer Process." (Lecture I.)

Chemical Industry (London Section), Burlington-
house, W., 8 p.m. Mr. R. W. Wallace, "Electrical
Industries at the Foyers Waterfall."

Imperial Institute, South Kensington, 8½ p.m. Mr.
E. A. Fitzgerald, "The Alps of New Zealand."

Geographical, University of London, Burlington-
gardens, W., 8½ p.m.

Sanitary Institute, 74A, Margaret-street, W., 8 p.m.
Dr. Alfred Hill, "Diseases of Animals in Relation
to Food Supply."

Medical, 11, Chandos-street, W., 8½ p.m.

TUESDAY, MARCH 15 ... SOCIETY OF ARTS, John-street,
Adelphi, W.C., 4½ p.m. (Foreign and Colonial
Section.) Mr. Neville Lubbock, "The West
Indies and Sugar Bounties."

Royal Institution, Albemarle-street, W., 3 p.m.
Professor E. Ray Lankester, "The Simplest Living
Things." (Lecture IX.)

Civil Engineers, 25, Great George-street, S.W.,

8 p.m. Mr. Henry Fowler, "Calcium Carbide
and Acetylene."

Statistical (in the Theatre of the United States
Institution), Whitehall, S.W., 5 p.m. Miss
Collet, "The Collection and Utilisation of Official
Statistics bearing on the Extent and Effects of the
Industrial Employment of Women."

Pathological, 20, Hanover-square, W., 8½ p.m.

Photographic, 12, Hanover-square, W., 8 p.m.

Mr. W. H. Lascelles, "Half-Tone Negative
Making."

Zoological, 3, Hanover-square, W., 8½ p.m.

G. Stewardson Brady, "New or Imperfectly
known Species of Ostracoda, chiefly from the
Zealand." 2. Mr. E. H. J. Schuster, "A new
Flagellate Protozoan of the Genus *Lophomonas*."
3. Mr. J. T. Cunningham, "The Early Post-Larval
Stages of the Crab (*Cancer pagurus*), and the
Affinity of that Species with *Atelecyclus heteropus*."

WEDNESDAY, MARCH 16 ... SOCIETY OF ARTS, John-street,
Adelphi, W.C., 8 p.m. Mr. Clayton Beadle, "The
Recent History of Paper-making."

Meteorological, 25, Great George-street, W., 8 p.m.
7 p.m. Mr. Arthur W. Clayden, "Photographic
Meteorological Phenomena."

Microscopical, 20, Hanover-square, W., 8 p.m.
Mr. C. F. Rousselot, "Exhibition of Microscopic
Rotifers."

Archæological Association, 32, Sackville-street, W.,
8 p.m.

THURSDAY, MARCH 17 ... Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Dr.

E. B. Poulton, "Natural Selection: the Cause of
Mimetic Resemblance and Common Warning
Colours." 2. Dr. Elliott Smith, "The Brachiopod
the Edentata, including Chlamyphorus."

Mr. Clement Reid, "Limnocarpos: a new genus of
Fossil Plants from the Tertiary Deposits of
Hampshire."

Chemical, Burlington-house, W., 8 p.m.

Drs. Winifred Judson and J. Wallace Wetherill, "The
Reduction of Bromic Acid and the Law of
Mass Action." 2. Drs. R. S. Morell and M. M.
Crofts, "The Action of Ferric Chloride on
Etheral Salts of Ketone Acids." 3. Mr. C. J.
Porter, "Note on the Volatility of Sulphur."
Drs. George Young and Ernest Clark, "Action of
Ammonia and Substituted Ammonias on Acetone
ethane."

Royal Institution, Albemarle-street, W., 3 p.m.

Prof. J. A. Fleming, "Recent Researches in
Magnetism and Diamagnetism." (Lecture I.)

Historical, 28, Jermyn-street, S.W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W.,
8 p.m. ("James Forrest" Lecture.) Professor
W. Boyd Dawkins, "Geology in Relation to
Engineering."

Sanitary Institute, 74A, Margaret-street, W., 8 p.m.

Dr. H. Kenward, "Infectious Diseases and
Methods of Disinfection."

FRIDAY, MARCH 18 ... Royal Institution, Albemarle-street, W.,

8 p.m. Weekly Meeting. 9 p.m. Mr. James
Mansergh, "The Bringing of Water to Birmingham
from the Welsh Mountains."

East India Association, Westminster Town Hall,
S.W., 4 p.m. Sir William Wedderburn, "The
Cultural Banks for India: Practical Experiments
Wanted."

Quekett Microscopical Club, 20, Hanover-square,
W.C., 8 p.m.

SATURDAY, MARCH 19 ... Royal Institution, Albemarle-street, W.,
3 p.m. Professor Walter Raleigh, "English
Letter Writers." (Lecture III.)

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FRIDAY, MARCH 18, 1898.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****CANTOR LECTURES.**

On Monday evening, 14th inst., Professor V. NOEL HARTLEY, F.R.S., delivered the 1st lecture of his course on "The Thermo-chemistry of the Bessemer Process."

The lectures will be printed in the *Journal* during the summer recess.

FOREIGN AND COLONIAL SECTION.

Tuesday afternoon, March 15, 1898; Sir ROBERT ROLLIT, M.P., LL.D., in the chair.

The paper read was "The West Indies and the Sugar Bounties," by NEVILLE LUBBOCK.

The report of the meeting will be published in the number of the *Journal* for April 1.

LINDE'S APPARATUS FOR LIQUEFYING AIR.

Dr. Linde's apparatus for liquefying air, which was described by Professor Ewing in the paper read before the Society on Wednesday, March 9, was shown in action in the Library of the Society on the afternoons of Monday and Tuesday, the 14th and 15th inst., and was inspected by a number of visitors. The pump working the apparatus was driven by an electric motor, kindly lent for the purpose by Messrs. Siemens Bros. and Co., Limited. The apparatus itself was in charge of Dr. F. Linde, who was assisted by Mr. Lightfoot, of the Linde British Refrigeration Co., Limited.

THE ALBERT MEDAL.

The Council will proceed to consider the award of the Albert Medal for 1898 early in the next, and they, therefore, invite members of the Society to forward to the Secretary, on

or before the 9th of April, the names of such men of high distinction as they may think worthy of this honour. The medal was struck to reward "distinguished merit for promoting Arts, Manufactures, or Commerce," and has been awarded as follows in previous years:—

In 1864, to Sir Rowland Hill, K.C.B., F.R.S.

In 1865, to his Imperial Majesty, Napoleon III.

In 1866, to Michael Faraday, D.C.L., F.R.S.

In 1867, to Mr. (afterwards Sir) W. Fothergill Cooke and Professor (afterwards Sir) Charles Wheatstone, F.R.S.

In 1868, to Mr. (afterwards Sir) Joseph Whitworth, LL.D., F.R.S.

In 1869, to Baron Justus von Liebig, Associate of the Institute of France, For. Memb. R.S., Chevalier of the Legion of Honour, &c.

In 1870, to Vicomte Ferdinand de Lesseps, Member of the Institute of France, Hon. G.C.S.I.

In 1871, to Mr. (afterwards Sir) Henry Cole, K.C.B.

In 1872, to Mr. (afterwards Sir) Henry Bessemer, F.R.S.

In 1873, to Michel Eugène Chevreul, For. Memb. R.S., Member of the Institute of France.

In 1874, to Mr. (afterwards Sir) C. W. Siemens, D.C.L., F.R.S.

In 1875, to Michel Chevalier.

In 1876, to Sir George B. Airy, K.C.B., F.R.S., late Astronomer Royal.

In 1877, to Jean Baptiste Dumas, For. Memb. R.S., Member of the Institute of France.

In 1878, to Sir Wm. G. Armstrong (now Lord Armstrong), C.B., D.C.L., F.R.S.

In 1879, to Sir William Thomson (now Lord Kelvin), LL.D., D.C.L., F.R.S.

In 1880, to James Prescott Joule, LL.D., D.C.L., F.R.S.

In 1881, to August Wilhelm Hofmann, M.D., LL.D., F.R.S., Professor of Chemistry in the University of Berlin.

In 1882, to Louis Pasteur, Member of the Institute of France, For. Memb. R.S.

In 1883, to Sir Joseph Dalton Hooker, K.C.S.I., C.B., M.D., D.C.L., LL.D., F.R.S.

In 1884, to Captain James Buchanan Eads.

In 1885, to Mr. (afterwards Sir) Henry Doulton.

In 1886, to Samuel Cunliffe Lister (now Lord Masham).

In 1887, to HER MAJESTY THE QUEEN.

In 1888, to Professor Herman Louis Helmholtz, For. Memb. R.S.

In 1889, to John Percy, LL.D., F.R.S.

In 1890, to William Henry Perkin, F.R.S.

In 1891, to Sir Frederick Abel, Bart., K.C.B., D.C.L., D.Sc., F.R.S.

In 1892, to Thomas Alva Edison.

In 1893, to Sir John Bennet Lawes, Bart., F.R.S., and Sir Henry Gilbert, Ph.D., F.R.S.

In 1894, to Sir Joseph (now Lord) Lister, F.R.S.

In 1895, to Sir Isaac Lowthian Bell, Bart., F.R.S.
In 1896, to Prof. David Edward Hughes, F.R.S.
In 1897, to George James Symons, F.R.S.

A full list of the services for which the medals were awarded was given in the last number of *Journal*.

Proceedings of the Society.

INDIAN SECTION.

Thursday, March 10, 1898; The Right Hon. SIR MOUNTSTUART ELPHINSTONE GRANT DUFF, G.C.S.I., F.R.S., in the chair.

The paper read was—

INDIA AND SIR HENRY MAINE.

BY CHARLES LEWIS TUPPER, C.S.I.

The principal object of this paper is to attempt to indicate some of the impressions which may be entertained by any Indian civil servant of fairly long experience in regard to the work which Sir Henry Maine, as a jurist and a statesman, did for India. He did so much for Indian policy, Indian administration, and Indian studies that any member of my service who is in a position to realise to some extent what Maine achieved in these matters might be excused if he ventured to record his gratitude. For myself, I may be allowed to say that I have had in the Punjab and in the Secretariat of the Government of India some special opportunities which have enabled me to trace the living and inspiring influence of Maine's ideas in certain fields of policy and administration open to the inspection rather of a few officials than of the great public concourse of learned men. I hope, therefore, to make to a well-known record some small additions of my own. Moreover, I heard Maine deliver in the hall of my college at Oxford the lectures which were published in his book entitled "Village Communities in the East and West;" and his pregnant suggestions have constantly guided my work in India, and throughout my life have chiefly inspired my studies, whenever I have been able to find time for any studies at all. For his far-reaching, penetrating, and illuminating genius I have a profound admiration; and I trust that the enthusiasm of my respect will be accepted as some justification for my entry on my present somewhat difficult and perhaps perilous venture.

I will begin with some biographical details. The most remarkable thing about Maine's life was that he was eminently successful in at least four separate capacities—as a professor, a journalist, a jurist, and a statesman.* His energies were expended in the dissemination of fruitful ideas; and, apart from his University successes and the honours which fell thick upon his later years, his career exhibits no striking personal incidents. He was indeed connected in philosophy, as a statesmanship, with historical tendencies; but not with historical events.

Henry Sumner Maine was born on August 18, 1822. From 1829 to 1840 he was at Christ's Hospital, and in the latter year proceeded to Cambridge as an exhibitor to Pembroke College, Cambridge. After a most brilliant University career, in which he was Senior Classic and Chancellor's Junior Classical Medallist, he became a Tutor at Trinity Hall, and at an unusually early age of 25 was appointed Regius Professor of Civil Law. In 1850 he was called to the Bar, and he was for some time Reader in Jurisprudence and Civil Law at the Middle Temple. He began to write periodicals as early as 1841, and was a constant contributor to the *Saturday Review* from the time of its first appearance in 1843. In 1861, when he was nearly 40 years of age, he published "Ancient Law," which at once made his reputation. In 1862 he was appointed Law Member of the Council of the Government of India, an office which he held till 1869. On his return to England he was elected Corpus Professor of Jurisprudence at Oxford, and in 1870 was appointed a member of the Council of the Secretary of State for India. He was created a K.C.S.I. the next year. In 1877 he became Master of Trinity Hall, Cambridge, and ten years later Whewell Professor of International Law at the same University. The dates of his works subsequent to "Ancient Law" were these: 1871, "Village Communities in the East and West;" 1875, "The Early History of Institutions;" 1883, "Early Law and Custom;" and 1885, "Popular Government." He died of apoplexy at Cannes on February 3, 1888, and his Cambridge lectures on "International Law" were published in September of the same year, the sheets being passed through the press by Mr. Frederic Harrison and Mr. Frederick Pollock.

* See, as to this, an article in the *Saturday Review* of February 11, 1888, quoted in Sir M. Grant Duff's volume, pp. 79 ff.

During Maine's tenure of office as Law Member of Council 209 Acts were passed by the Indian Legislature. We may see alike in India and in Japan that when progress in imitation of our own civilisation begins anew in a society popularly, but perhaps not rightly, described as a stationary society, the movements of centuries of normal growth may be compressed into tens of years. Thus India now advances very rapidly in legal development; and in the thirty years since Maine left India the greater part of the legislation of his day has been recast. This circumstance detracts in no way from his very high reputation as a legislator. It must be remembered that the legislative department of the Government of India is not an initiating department. Its function is to embody in the appropriate technical shape projects of law of which the policy has been approved by the Executive Government. Maine never attempted (it would, I think, have been entirely foreign to his character to attempt) to signalise his tenure of office by the enactment of any specially notable laws. With a sobriety of judgment and a sagacious self-control which distinguished him in all practical affairs, he limited himself to the actual requirements of his time; and, as he himself said, would indeed have welcomed any suggestion by which the amount of legislation falling to his hands could have been diminished. The great legacy which Maine left to India does not consist in positive enactments, but in luminous ideas and comprehensive principles to be gathered less from the statute-book than from his speeches and writings.

To borrow his own classification, most of the Acts which he passed fall into one or other of four groups.

First there was legislation "intended to bring up law which was common to England and India to the pitch of improvement which it had reached at home." In this class he instanced the Mercantile Law Amendment Act and the Indian Companies' Act. Here it may suffice to say that the great value of the mercantile legislation effected in his time was prominently acknowledged on the occasion of his resigning office at a meeting of the Council of the Governor-General.

Next there were enactments affecting the civil usages or religious opinions of the people of the country. In this class we may include the Bills he introduced or passed for the remarriage of native converts and for the civil marriage of natives; and it may be accepted on the

authority of Sir Alfred Lyall that "the whole spirit of our law-making in social reforms during the second half of the Victorian era may be traced" to Maine's influence.

The third class of Acts comprised the draft chapters of the Indian Civil Code, prepared by the Law Commission then sitting in England. Only one of these drafts, that relating to succession, was carried through Council by Maine himself; but he was, as I am about to explain, a most powerful advocate of codification.

The fourth class existed because the Imperial Legislature is also the Local Legislature for provinces which have not Legislative Councils of their own. There was a constant demand for judicial and other improvements affecting the machinery of the administration, and this demand had to be met by the Council of the Governor-General.

It will be best to consider these two classes of legislation together. They suggest the question what was the place occupied by Maine in the general development of Indian legislation which has occurred since the Mutiny.

That catastrophe caused the reconstruction of the army, and the re-establishment of the political system on a new foundation. It also hastened in law as in administration a reconstruction which was probably in any case inevitable. Our point of interest here is that legal development in India appears to illustrate some principles which Maine discerned in the course of legal history at large.

"Even jurisprudence itself," he said, "cannot escape from the great law of evolution." Progress, or at any rate the series of changes from barbarism to civilisation, proceeds from the simple to the complex; ideas, functions, sets of rights originally blended are separated as society advances. Thus in some early societies the ideas of law, morality, and religion are interfused not only with each other, but with cosmogony. If we take politics, we see that in early times the king is almost always a judge and a leader in war, and often a chief priest, these functions devolving separately on others as progress is made. If we take law, joint property precedes severalty, status precedes contract, the unit of ancient society is the group, of modern society the individual; and a great part of legal history is the history of the growth of individual right. Such are some of Maine's doctrines or inferences which could be drawn or defended from his writings. I have said

nothing here which could not be illustrated from Indian facts; but any extensive verification or criticism of Maine's opinions by the aid of Indian experience would require not such a paper as the present, but a good many essays or even volumes. At the moment I have merely to show that the main principle, which underlies these doctrines is illustrated by the history of legislation in India.

Let us take for instance the disentanglement of the blended strands of authority. By letters patent of 1726 the local governments at Madras, Bombay, and Fort William, which were of course executive authorities, were constituted courts of appeal in civil cases, and required to hold quarter sessions for the trial of all offences except high treason. After considerable vacillations in the judicial arrangements for Bengal, we find the Governor-General and the members of Council final judges of appeal in 1801, when their powers in this behalf were transferred to a chief judge and puisne judges. The Governor of Madras ceased to be a judge only in 1807. The Governor of Bombay in Council exercised certain appellate powers till 1827. The union of legislative and executive powers lasted much longer, and in a sense lasts still. Till 1833 the regulations of the three presidencies were edicts having the force of law emanating from executive authorities. Even then for twenty years there was no distinction between the executive Council and the legislative Council of the Governor-General except that the Law Member had power to sit and vote only when meetings were held for the purpose of making laws. In 1853 for this purpose new members were added, two of them Judges of the Supreme Court at Calcutta, and the others appointed severally by the local governments. At this time also discussion became oral. The year before Maine came to India the Indian Councils' Act was passed, which, as amended in 1892, regulates the present system. During Maine's period of office the only remnant of judicial authority left in the hands of the Governor-General was that which is still held by the Crown in this country in the shape of the prerogative of pardon. But in Maine's time certain legislative authority could be exercised by the Governor-General alone, and can now be exercised by the same authority or by the Governor-General in Executive Council. Under the 23rd section of the Act of 1861 the Governor-General alone can, in cases of emergency, make ordinances having the force of law to run for not more than six months;

and under a Statute of 1870, to which I shall refer again, the Governor-General in his Executive Council can make regulations having the force of law for wild and backward tracts. This statute was passed just after Maine's time, but largely on his initiative.

If we look lower down below the summit of government we shall still see the same process at work—the gradual fission and specialisation of public authority. Maine marked and noted with emphasis the decay in his day of discretionary administration all over India. The discretionary, or, as it was also called patriarchal rule, was a modified version of the personal rule of our predecessors, and involved down to the base of the official pyramid something like the same union of powers which I have described as existing at its apex. The despatch of March 31, 1849, which constituted the Punjab Board of Administration, directed that every civil functionary, from the Board to the *Kardar*, should be invested with judicial, fiscal, and magisterial powers. The Chief Commissioner of the Punjab issued numerous circulars which were practically law. Even the early Deputy Commissioners were not only judges and governors of districts or counties, they were also law-givers in so far as they acted in legal matters on rules of their own devising. Very soon laws were prescribed for them by the Board of Administration or the Chief Commissioner; and by the time Maine came to India discretionary administration had yielded to new forces even in the Punjab, once its great stronghold. This kind of administration, as Maine pointed out, "is inconsistent with the existence of regular Courts and trained lawyers." But he added that since these must be tolerated, the proper course is to discover expedients by which the tendency of legislation to hamper discretion may be minimised. He deserves, I think, the gratitude of all district officers for making that remark.

The sense of individual right in proportion to its strength is opposed to discretionary administration. The growth of this feeling in India is a matter of common observation, and it is a part of the general change which includes the decadence of personal rule. We see in many parts of India, either actually proceeding or as an accomplished fact, the disintegration of the tribe, the village, the joint family. Tribal or village committees cease to be the arbiters of disputes, because every man may lay his claim in the nearest law court. Under the *pax Britannica*, tribal

village cohesion is no longer necessary for protection in chronic warfare, and grows less necessary than it used to be for protection against open brigandage. The enhanced value of joint property suggests and stimulates partition. Enterprise, prompted by education and facilitated by railways and good roads, draws villagers from one part of the country to another, and turns the son of the peasant into the cutcherry clerk, or newspaper writer, or petty advocate. In many provinces we transmute relations, many of which it is no metaphor to term feudal relations, between chief and vassal, peasant proprietor and serf, or between different classes of peasant proprietors, into a new world of landlord and tenant, giving new names to old things which have already changed and inevitably change still more as we handle them. We remark that the units of ancient society are groups, and of modern society individuals, is a measure confirmed when we see that civilisation itself is the solvent of old-world ties in India. The activity of legislatures, the regular working of the Courts, the bar, the schools, and the universities, all promote the growth of individual right. The improvement of communications between India and England induces the servants of Government to promote change partly because we are less orientalised than we used to be, partly because, with or without any cause, we grow more and more anxious to be able to justify what we do by arguments which will commend themselves to English public opinion.

All this means the impact of Western civilisation, and in Maine's day it led to a twofold demand for new laws. Legislation is necessary to support proceedings which till long before would have been regulated by mere executive orders; and greater commercial activity and free resort to the Courts disclosed gaps in the legal system which were being partially and awkwardly filled up, almost at haphazard, by disjointed fragments of English law. The Courts, under the name of justice, equity, and good conscience, took their law from English text-books when they had no other guide. Putting aside the religious law, including the law of succession and the land law, there was really very little law in the country, and the little Maine found was vague and conflicting. He argued that legislation is the process which perpetually goes on wherever there is a civilised government; that if you will not have legislation by the Legislature, you will have legislation by the Courts—the process which could not be controlled by

considerations of expediency. His remedy was “a code which, without going overmuch into detail, should set forth fundamental principles with as much simplicity as was compatible with accuracy.” Such a code, he said, “would perfectly well fit in with native usage when it was wholesome; nor was there any fear that English law, characterised as it was by good sense and logical coherence, would fail to supply the greatest part of the material.”

Such was Maine's view on the important question of codification in India. As to the actual course of legislation it seems to me to illustrate the contact of civilisation with archaic societies awakening to new forms of life, and the possibility of extraordinarily rapid progression when certain conditions are fulfilled. I may condense some of Maine's conclusions by saying that in many early societies the bulk of the law consists of penal law and procedure. As between the primitive groups, there is robbery and bloodshed; within the primitive groups, rights are neither disentangled nor defined, and as yet their definition is far less important than the means of redress. For the means of redress you want a procedure, and to check the violence—a penal law. Now when we actually began codification in India two or three years before Maine got there, the laws we passed were the Indian Penal Code and the Codes of Civil and Criminal Procedure. In most parts of India the things most needed are to keep the peace, to suppress violent crime, and to provide simple means of redress in simple cases; and I do not believe it was by mere accident that we thus met the primary legal wants of the miscellaneous archaic societies under our Government.

The subsequent movements resulted from the joint operation of complicated forces, and can be mentioned here only in very brief and general terms. The era of codification lasted till 1882, though the process itself of codification was to a slight extent resumed in 1890. Many of the Acts regarded as forming part of the Indian Civil Code are limited to special classes, chiefly to European or Europeanised classes, or for some other reason have as yet no considerable effect amongst the many millions of peasants who make up the mass of the native population. But two chapters in the Code stand out in prominent relief—the Law of Evidence and the Law of Contract. Now the Law of Evidence was required to complete procedure, and the Law of Contract to meet that growth of individual right which we have stimulated in India.

But how are we to justify the production of a Law of Contract, the symbol and fruit of mature civilisation, so soon after a penal law and a law of procedure supplying the primary needs of archaic communities? The answer is that civilisation had not been the slow, indigenous growth of ages, but had, in terms of historic time, quite suddenly been brought to those communities from without. They had little or no provision for a commercial activity protected by the operation of regular Courts and enormously extended by peace and security, by railways and telegraphs and good roads. Moreover, in proportion as individuals sever themselves from the tribe, the village, or the joint family, and assert their separate rights, they pass out of a circle where custom holds each in his place into a sphere where the regulative force is contract.

One movement, then, the movement of codification, may be summed up by its most conspicuous results—a Penal Law, a Law of Procedure, and a Law of Contract. But while the era of codification was at its height, another era, that of local laws, had already begun. Two tendencies, I think, are now at work, and both illustrate the specialisation of functions or systems which accompanies development. We are localising legislation, and we are—more often as yet through the central than through any local legislature—supplying local needs, province by province, by passing local laws, some of them containing important provisions of substantive law, but most of them constituting or elaborating the machinery of administration.

When in 1853 a true legislature first appeared in India, the powers of legislation, formerly exercised by the Governments of Madras and Bombay, had been concentrated since 1833 in the Council of the Governor-General. Nor was the stream of legislation thus drawn into a single channel again severed till 1861. Legislatures were then constituted for Madras, Bombay, and Bengal, and have long since Maine's day been constituted for the North-West Provinces, the Punjab, and Burma. Of local laws, I may instance the Laws' Acts, the Courts' Acts, and District Board and Municipal Acts of many provinces; and more important than any of these the series of local Acts by which during the last seventeen years either the law of landlord and tenant, or the land revenue law, or both, have been thoroughly revised in the whole of Northern India.

I can now attempt some answer to the

question what was Maine's place in the history which I have imperfectly sketched. Maine came to India at the height of the period of Code-making, which began with the appointment of the first law commission in 1834, and ended with the passing of the Transfer of Property Act in 1882. It did not fall to his lot greatly to advance the Code, specific enactments, but no one more clearly perceived or forcibly defended its necessity. There had been a true legislature in India since 1853, but it had till 1861 been a legislative Council. Maine saw the commencement of the era of the local legislatures, and in the Punjab Tenancy Act and the Oudh Tenancy Act the commencement of a most important era of local laws. He perceived the decay of discretionary administration, and saw that the transition ought to be dealt with by the legislation which should not destroy discretion where that ought to be maintained. The changes which were proceeding in his mind were expedited, not caused, by the Mutiny. The constitutional change, however, in the system of government directly due to the Mutiny supplies me with a phrase to sum up the position. I think that in the department of law Maine was the presiding genius of the transition from India of the Company to India of the Queen.

I pass now from Maine the Law Member of the Council to Maine the writer of books. He never constructed a complete science of jurisprudence, still less a complete science of sociology. His works have been described as groups of essays rather than systematic treatises; but they appear to me to possess certain unity. He never published a revised edition of "Ancient Law," but that work contains the germinal ideas out of which all his he wrote was unfolded. Why was he concerned with the relation of early legal ideas to modern thought? For one reason, though very far from being a party politician, he was interested in the political tendencies of our time. He perceived the connection between the modern Law of Nature—the progeny alike of International Law and of the ideas of the French Revolution—and the Stoic Law of Nature, the goal of legal progress in antiquity and Rome. It was by this route that he was led to the consideration of modern democracy and of unrealised ideals for the restriction of its influence upon the affairs of mankind. But these theories of a Law of Nature, which have been so enormously disproportioned to the facts of life, were also theories of jurisprudence.

they were in truth mere figments of the mind there was a sound philosophy of jurisprudence to be found? Maine answered in the history of law interpreted by a scientific method; and especially in the history of early institutions, because they are simplest in form and contain the germs of the institutions of the modern world. This led him to examine Roman law as a typical system, and to compare the Roman and other ancient systems of law and of property with each other. Conspicuous amongst these other ancient systems were those easily open to view in India. Even when he was decorating the temple of history with the classic frescos of "Ancient Law" he occasionally used some Indian colour; and, indeed, there is in that book one small study of the Indian village community which is equal to anything Maine subsequently gave us on the same theme. But it was in the three books that Maine wrote next after his return from India that his Indian experience was ever present with him. He passed in review the Ash tribe, village institutions in the East and West, including the mark and the manor, and some of the many forms of the family—the Roman patriarchal family, the Hindu joint family, the East European house community, and, far earlier structurally than any of these, the gynandrous arrangements and systems of other-kin elucidated by Lubbock, Morgan, and McLennan. In nearly all of these he saw some principle of development, and in explicating it used freely two great Indian institutions—the village and the joint family. The Indian tribe or caste and the Raj or principality he hardly touched. In the only important passage where he did speak on the formation of clans and castes in India, he relied on essays from the pen of a writer on Indian subjects, who, if I may venture very respectfully say so, stands on the same level with Maine himself as an interpreter of archaic societies. Maine said that a new epoch began in certain Indian investigations when Sir Alfred Lyall was appointed Commissioner of Berar; and I think all Indian civil servants who have read "Asiatic Studies" would be likely to concur in that observation.

I remember being told at Oxford, in the year 1870 or thereabouts, that Maine was anxious to write his "Village Communities" before he forgot what he had to say. It was delightful to hear of something so entirely human in one I regarded as so great. The last chapter of that book is, I think, from an Indian point of view, one of the most important

that he ever wrote. India, he said, is "the great repository of verifiable phenomena of ancient usage and ancient juridical thought;" but everything characteristic of it is being quickly spoilt for scientific purposes by the influx of Western ideas. It behoved us, therefore, to examine Indian usages before it was too late. He ended by saying—"It is by its indirect and for the most part unintended influence that the British power metamorphoses and dissolves the ideas and social forms underneath it; nor is there any expedient by which it can escape the duty of rebuilding upon its own principles that which it unwillingly destroys."

But what are some of the principles upon which this work of reconstruction is being carried out? One is the principle of the Law Commissions—the adaptation of simplified and it may be improved versions of English law to the conditions of native society. That is probably an inevitable principle, where India supplies no materials, or very scanty materials, for the legislature to take in hand. Another is that the country must be governed in harmony with the established usages of the people, so far as those usages are not flagrantly opposed to our ideas of right and wrong, as, for instance, in the cases of female infanticide and *sati*. On this principle there has been more metamorphosis than dissolution, and we have often repaired and modernised the dilapidated structures of our predecessors, or when we have rebuilt them have used the old materials for the job. Something like this we have done in several departments on an enormous scale throughout the country. Our administrative system—I mean our hierarchy of local governments, commissioners, district officers and their assistants, taken with the Courts linked to each other by a lengthy chain of appeal—is an inheritance from the Moghals, no doubt vastly strengthened and diversified so that it is with difficulty recognisable in its rehabilitated condition, now standing out with striking clearness in an unaccustomed atmosphere of law. Our land revenue system is a native system improved. The internal political system, that is, the system of relations between the British Government and the native States, is a strengthened reproduction of an important part of the Delhi Empire. I have shown what Maine held should be done where the land lies empty of the laws and institutions needed under the new conditions of civilised rule; and I propose now to trace some of our obligations to him in connection with those

systems where we have built on an Indian foundation with indigenous materials—the land revenue system, the political system, and the general system of administration.

As regards this last, I have already mentioned his advocacy of discretion where discretion can be allowed. Just as his keen historic insight enabled him to perceive how deep and broad a gulf lies between the semi-civilisations or barbarisms of different parts of India and the actual civilisation of the West, so also it brought home to him in what widely separated stages of growth stand the different sections of the Indian population and at what different rates of advance progress is possible, for instance, on the Pathan frontier or in the Presidency division, in the jungles of the Central Provinces, or in the suburbs of Bombay. It was in accordance with a despatch drafted by Maine—the draft is printed in the collection of minutes which forms part of Sir Mountstuart Grant Duff's volume of Maine's life and speeches—that the Statute of 1870 was passed, to which I have already referred. That Statute enabled the Government to give us the Punjab Frontier Regulations. When the Statute has been applied to any territory the local Government may propose draft regulations which can be approved in the Executive Council of the Governor-General, and thereupon acquire the force of law. This enactment has been of the utmost benefit to the Punjab frontier districts, and we probably have Maine to thank for it more than any one else. The point is the more noticeable because the Penal Code and the Code of Criminal Procedure having already been passed, Maine made few direct contributions to the criminal law of India. This indirect contribution has been, however, of very great importance. When in 1886 we consolidated and largely revised the regulations, producing the new edition of them which is contained in the Punjab Frontier Crimes Regulation, 1887, the influence of Maine's teaching was of the greatest use to us. I am in a position to say this with some confidence because I was secretary to the committee which prepared the Regulation, and drafted, under the instructions of the committee, both the Regulation itself and the report which accompanied it. We had to deal with an archaic tribal society, full of violence, prone to conceal crime, and eaten through and through with blood feuds. We had to deal with habits of mind, which not merely excused murder, but made the commission of it, in certain circumstances, a point of duty or

honour. Our legal remedies were primitive type, but adapted to civilised administration. We arranged, as before, to refer to Councils of Elders questions of guilt or innocence, and, as a new proposal, civil matters in dispute, when the dispute might lead to a breach of the peace. These councils are modelled on, but not exactly copied from, those *jirgas* of tribal councils, which have been of late conspicuous in the Afridi war. Moreover, we greatly enlarged the law of security. Doubtless we looked back to another ancient society to a time in this country when jurymen were effect witnesses, and when, by the system of frankpledge, the men of a tithing were responsible each for any offence of any of the rest. We did not, of course, pedantically try to imitate Anglo-Saxon, or, as it is, I believe, more correct to say, Anglo-Norman institutions. We based our project on the facts we found. But that Maine had taught us to compare one archaic society with another, and to accept as part of the course of nature some of the differences between tribal and civilised society, helped us both in understanding the case and in reporting it.

Another service for which we in the Punjab at any rate, owe him much, is his diagnosis of the relation of Hindu law to the customary law of the country. Originally our Courts, and, indeed, our Parliament, supposed "that the sacerdotal Hindu law corresponded nearly to the English common law, and was at least the substructure of all the rules of life followed by Hindus." But it came in time to be perceived that Hindu law was, with some local variations, but one set of customs which Brahman expositors had manipulated for their own purposes, and that there were large bodies of local or tribal custom in existence outside the range of the written law. This is the view taken by Maine,* and it is, I think, a matter of consequence to the administration of justice that it has the sanction of his high authority.

Passing from the Courts to the Revenue Department, I note some other great service done by Maine. Not the least of them is that he prepared the minds of scholars in Europe for the reception of the sort of evidence which Indian revenue officers are able to supply; whilst at the same time he helped in India to maintain or re-establish mental contact with educated men at home. "The conviction," he said, "is that what is wanted to unveil the stores of interest contained

* "Early Law and Custom," pp. 6-7. "Village Communities," pp. 52-3.

India is, first, some degree of sympathy with an ignorance which very few felicitous efforts have yet been made to dispel, and next the employment of a phraseology not too highly specialised." He set us an excellent example in these respects in his many allusions to things Indian. In particular his brief explanation of the nature of Indian settlements and of the Indian judicial system* are, I venture to think, amongst the most felicitous attempts to lighten the English public on the elements of Indian affairs that exist in English literature.

Of the three great branches of our revenue system—the assessment of the Government land, the framing of the Record of Rights, and the regulation of the status of landlords and tenants—I am not aware that Maine ever handled the first; nor, indeed, was it any part of his work, either as jurist or statesman, to do so. I distinguish between the preparation of the Record of Rights and the Law of Landlord and Tenant because that law, mainly the creation of British rule, has acquired a separate place both in fact and in the Statute-book; though, of course, the specification of rights relating to agricultural land includes the definition of those peasant rights which were discriminated in Western phraseology. Of the two famous controversies relating to land right which occurred in his time, Maine handled an important part. But I have no space here to review the Oudh Talukdari question, or the question of Punjab tenant rights. I will merely say that the speech on the Punjab question, reprinted in Sir Mountbatten Grant Duff's book, is, I think, the best ever read in the debates of the Legislative Council in India, and that even now, after the lapse of thirty years, it is well worth the study of Punjab revenue officers.

Of other ways in which Maine has influenced the definition of rights in land effected partly by the Settlement officers, partly by the Courts, and partly by the Legislature, I will mention two: one known to all the learned world, and the other probably only to few or none besides Punjab officials. When I came to the Punjab one of the documents which I picked up the Record of Rights was known as the Village Administrative Paper. This document was partly a record of village custom relating to land and its produce, and partly a written agreement for term of settlement. Amongst other customary rules, it included one regarding succession and adoption.

* See "Village Communities," Lecture II.

In 1865 the practice began of recording such customary rules for tribes instead of for villages, and in this way a part of the old Village Administration Paper has expanded into the Statements of Tribal Custom, which are now always prepared at time of settlement. Between 1873 and 1880 the work of investigating Punjab tribal custom was systematised, and the duty of framing the questions which were to be used for the purpose was entrusted to me. I brought the subject up to date in 1880, and have since examined the results of subsequent inquiries made through the Settlement Department. I am thus in a position to say first that the very extensive inquiries which have been made were partly suggested and certainly stimulated by Maine's opinion that Indian usage, already crumbling under the pressure of our system, should be studied quickly if its study was to be of scientific use; and, secondly, that his doctrines of the evolution of property, and of the law of the family and of succession, have been of inestimable value to us in our endeavours to formulate the principles of Punjab tribal law.

The achievement known to the learned world is Maine's account of the early history of property, the process of feudalisation, and the decay of feudal property in France and England. This includes his description of the Irish tribe, and his discussions of village communities in the East and West. The subject, in fact, is nothing less than his view of the general history of property in land. In one section of this extensive field of research a whole literature has sprung up chiefly, though not exclusively, from seed of his sowing. Phear, Seebohm, Gomme, and Baden-Powell, amongst others, have all written on the village community, and all acknowledge their obligations to Maine. One effect in India of Maine's teaching here is that we can never again confound Indian and English ideas of landed property. Much work has already been done, and more will I hope be done in the way of examining or re-examining the numerous forms of landed property existing in the various districts or provinces of India with a view to fixing some place for each form in some order of development. We may not be agreed what that order is, and perhaps many or most of us may think that there is no one universal order, but that severalty, like civilisation itself, or like the adaptation of species to their environments, has been attained, doubtless under the operation of natural laws, which may be

discoverable, but, nevertheless, by very varied and complex processes in different parts of the world. Many who are interested in the history of property will perhaps feel with me that Maine started us on the right path of inquiry, even if it was not given to him to prophecy to what points it would lead various inquirers in narrower fields. In so far as we assimilate Maine's method, I think our work will be improved; and it certainly adds vastly to its interest to be able to feel that accurate descriptions of Indian forms of property are real contributions to modern science.

I have reserved for the close of this paper the two greatest services, as they appear to me, which Maine rendered to India. Here I speak of Maine both as author and statesman, and I have again to make a distinction similar to that which I made just now. One service was done to India in particular, and to the British Empire through India; that is known, I believe, at present only to a few specialists. The other was done to science, and is generally known to men of learning. In that service India merely has her share.

Maine more than any other person I can name facilitated the development of the Indian political system. The principles of that system were not settled till after the Mutiny. Doubtless it had been understood from the beginning of the century that the British Government was the paramount power, and this position had involved the control of the foreign relations of native States. But that the policy and practice of the Government of India in its relations with native States were quite unsystematic up to the time of the Mutiny will be readily seen from the abstract of the discussions on the annexation of Oudh, and of Lord Canning's despatches on the adoption question, which I gave in a book published in 1893. It is true that Lord Dalhousie, firmly believing in the superiority of British rule, was in favour of taking every just opportunity to incorporate State territory with the British dominions. But his policy of annexation was most wisely abandoned. One fundamental principle of the system which now exists, the principle that the preservation of native rule is desired by the British Government, was declared in the Amnesty Proclamation of 1858, and in the promises to recognise adoptions of their successors made by ruling chiefs contained in *Sanads* issued on the departure of Lord Canning from India in March, 1862. Two other fundamental principles were laid down by Maine in his minute on the Kathiawar

States, published in Sir Mountstuart Grant Duff's volume. Maine pointed out that where sovereignty is divisible, independence is not; and that the mode or degree in which sovereignty is distributed between the British Government and any given native State is always a question of fact, which has to be separately decided in each case. It follows that there is in India only one independent sovereign—the British Government. The sovereignty of ruling chiefs is always limited. To one or other of the principles I have named, including the acquisition before the Mutiny of a supremacy which comprised the whole of external sovereignty, may, I think, be referred all, or nearly all, the rules and principles affirmed in a long series of decided cases from 1860 to the present day. The formation of the present system—a system wise, humane, and untouched by sinister or party influences—have long regarded as one of the greatest, though least known of the achievements of the British Government in India. The enormous range of this benignant work is evident from familiar statistics. The native States contain about one-third of the area, and not much more than one-fourth of the population of India, and they are governed by more than 600* ruling chiefs. The vast, intricate, and varied nature of relations between these numerous States and the British Government is on the whole being reduced to the sort of symmetry which belongs to international law. Maine helped in this process chiefly by the judicious application of rules drawn from international law to a sphere where that law as such and as a whole is excluded by the suzerainty of the Queen. "If he did in numerous papers, of which four have been published. Fortunately, the Kathiawar minute is amongst these. That minute is an excellent illustration of the co-ordinating energy of Maine's ideas. In the ordinary course of business he laid down two principles; and forthwith fragments of old India of the Rajas which preceded it has in places survived Moghal supremacy, a great mass of the broken Empire of Delhi, and some more or less amorphous structures raised on a Hindu basis by Mahratta conquerors of Mohammedans, began to be rearranged by many successive hands on principles in harmony with the history of India, and capable of clear statement. Or, if we look to the results in our own minds, a whole assembly of notions, dim, ill-conceived, and jum-

* The Indian Statistical Atlas gives the number at 614. The return prepared in the Foreign Office, in 1893, at 703.

gether, began, at his initiative, to take upon themselves a lucid and orderly arrangement, and to draw to themselves others to be ranged to the same equal effect, the whole process resembling the formation of a disciplined army out of a mob by the reiteration of words of command. The eminent service to science, in which India has her share, is that Maine taught the application of a really scientific method in historical and sociological inquiries. If India is indebted to Maine as a jurist and a statesman, Maine as a jurist was indebted to India, as he has himself explained. He looked on a whole science a whole stage in advance, and besides this, contributed largely to the formation of a new science. Montquieu, he held, had pointed out, had indeed restated, the effect of the environment on institutions; Bentham and Austin had attempted to construct a system of jurisprudence on the strictly scientific process of "the observation, comparison, and analysis of the various legal conceptions." But I do not suppose there will be any dissent from Maine's remark that what had stood before his time in the place of a science of jurisprudence had been, with these exceptions, for the most part a mere set of guesses. India, as Maine said in his Rede Lecture for 1875, gave to the world comparative philology and comparative ethnology; and it was comparative philology which suggested to Maine the science of comparative jurisprudence. That again brought him to the threshold, perhaps beyond the threshold, of sociology, though he refrained from giving to the new science, which he saw, that or any other name. In India, he said, are the materials for this new science, its world "of Aryan institutions, Aryan customs, Aryan laws, Aryan ideas, Aryan effects, in a far earlier stage of growth and development than any which survive beyond the borders." So true is it that one discovery leads on to another, that had it not been for William Jones and the study of Sanskrit, we might never have written "Ancient India." As it was, Maine stood between the East and the West, between the present and the past, the interpreter alike of archaic and modern ideas. Gibbon's History has been compared to an undecaying arch spanning the abyss between the old world and the new. He bridged the same gulf in the region of science; and he did more, for he laid down permanent lines of mental communication between the students of two continents. He brought the results of European research and

intellect to bear upon practical problems of Indian administration; and he brought the results of Indian researches to bear upon modern European thought. He said that the theory of the common Aryan parentage of Englishman and Hindu—a theory derived from comparative philology—made Indian government easier. I do not dispute that assertion, but I could not myself make it with any confidence. I am, on the other hand, sure that when Maine said that "institutions, like forms of organic life, are subject to the great law of evolution," he did enunciate a principle which has greatly lightened our task, and is likely to lighten it more and more as the principle itself becomes more widely accepted. Mutual tolerance, for instance, is easier when educated Indians and Europeans perceive that India of to-day teems with analogies to the past of Europe. And the conception of stages of growth in society leads directly to the conviction that the institutions of any community should correspond to its existing stage of growth, though they must be varied in novel environments. Maine was, so far as I know, the first to turn the bright light of this principle of evolution upon the already melting mists which shroud and distort Indian facts under Western observation. In his case a part of the saying of Mark Antony is reversed, for the good that Maine did to India lives after him, and we have not yet gathered all of its fruits.

DISCUSSION.

The CHAIRMAN said:—I am sure any friend of Sir Henry Maine who may be present will have listened with great pleasure to the testimony that has been borne to his genius by one who has been long in contact with the facts of Indian country life. Maine never had much opportunity of coming into contact with these. His knowledge was gathered from reading and conversation; he saw with the eyes of others. Such, however, was his marvellous power of divining the truth, that, as Mr. Tupper has told us, before he ever set foot in India he had written admirable pages about the Indian village system. Mr. Tupper has said very truly that the great legacy which Maine left to India did not consist in "positive enactments, but in luminous ideas and comprehensive principles embodied in his speeches and minutes." I suppose it is quite certain that the form in which these "luminous ideas and comprehensive principles" appeared in the Statute-book, owed a very great deal to another extremely able man, Mr. Whitley Stokes. The reader of the paper has further told us that Maine was, in the department of the law, the pre-

siding genius in the transition of the government of the Company to that of the Queen. How little men can anticipate their fate. In the earlier days of my friendship with Maine he was the most brilliant writer on the side of the Court of Directors. I do not remember anything that he wrote at any later period more eloquent than a passage which I quoted from an article contributed by him to the *Saturday Review*, in the brief memoir affixed to his speeches and minutes, which was published some years ago. Mr. Tupper is perfectly right in saying that the Statute of 1870, which has been of so much service in the Punjab frontier districts, is more due to Maine than to any one else. I can say so with confidence because it was I who carried it through the House of Commons, and I was in constant communication with him about it. Very happy also is another remark of Mr. Tupper's: "Not the least of Maine's services is this, that he prepared the minds of scholars in Europe for the reception of the sort of evidence which Indian Revenue officers are able to supply, whilst at the same time he helped us in India to maintain or re-establish mental contact with educated men at home. 'My conviction,' he said, 'is that what is wanting to unveil the stores of interest contained in India is, first some degree of sympathy with an ignorance which very few felicitous efforts have yet been made to dispel; and next, the employment of a phraseology not too highly specialised. He set us an excellent example in these respects in many allusions to things Indian.' Excellent, too, was Mr. Tupper's reference to what Maine did for jurisprudence in following the lead of what had been done by others, in building up with Indian materials comparative philology and comparative mythology; but there are many here who are better fitted than I to discuss that, as well as a great many other topics touched on in Mr. Tupper's valuable paper, and I would call on one of these to continue the discussion. I see, for example, we have present to-day Mr. Frederic Harrison, who was one of the earliest—if not the earliest—of Maine's pupils in Stone-buildings, Lincoln's-inn, and who wrote a review of "Ancient Law," of which the author of that great work spoke to me, at the time it appeared, in the very highest terms. I will ask Mr. Harrison to continue the discussion.

Mr. FREDERIC HARRISON said they were dealing that night with Sir Henry Maine's work almost entirely from the Indian point of view, on which subject he (Mr. Harrison) had very little knowledge. It was his privilege when a young law student to listen to the lectures given in the Middle Temple Hall, which eventually became the work on Ancient Law. These lectures had filled him with the deepest admiration and interest. He had been one of those who urged the publication of Sir Henry Maine's work, which it was believed would be likely to have great influence on the thought of the day. He would only say that the admiration and regard that he had for Sir Henry Maine's work while a student of his

had been developed throughout the whole of his life, and he rejoiced to see so distinguished an audience gathered together to listen to an eloquent paper dealing with the life-work of one who had been a master to many of them, and a friend to all.

Mr. W. LEE-WARNER, C.S.I., while acknowledging the admirable character of the paper just read, wished to press one point rather further than Mr. Tupper had done. Sir Henry Maine was only eight years of age when Sir John Malcolm wrote a brilliant memoir on the advantages of preserving the native States, and even before Maine's birth, British courts of law had ruled that the extent of sovereignty possessed by a nation was a question of fact. The third principle attributed to Maine, namely, the divisibility of sovereignty, was denied, it is true, by nearly every authority of the day, whether German, French, or English; but the warmth with which John Austin repudiated the "political mongrel" of a semi-sovereignty State showed that there were some at least, worthy of attack, who held the view. Maine was, therefore, not the founder of these three principles mentioned by the reader of the paper, but he was essentially a great man who adopted and illuminated, and so enabled others to adopt, the fundamental principle that the attributes of sovereignty are many, and that the native States can be regarded as semi-sovereign in respect of those attributes, or parts, of all sovereignty which they do possess in a greater or lesser degree. In the present day there were some who avoided Maine's conclusion by regarding the semi-sovereignty of the native States as constitutional and not international. The distinction was one of considerable importance. That Maine referred to international conceptions when he placed the native States in the category of semi-sovereignties was clear from the Minute on Kathiawar, printed at page 10 of the Chairman's memoir. He wrote: "I am clearly conscious of the difficulty of applying international rules and international conceptions in India, but that difficulty must be faced, my opinion is that the Kathiawar States enjoy some measure (although a very limited measure) of sovereignty; and that, therefore, the territory they include is properly styled foreign territory." In other words, these conceptions of international law led him to recognise these States as in a measure foreign territory. More practical and explicit was his conclusion that, "on the assumption that international rules in some sense or other apply to the case," therefore the British Government was bound with due regard to international rules, by its own disclaimer of sovereignty, "until a new state of things arises through war or treaty," which, it is to be observed, are the essential methods of change known to international law. The full significance of this view is best appreciated by reference to the court cases and able criticisms of Professor Westlake on a most valuable contribution to the subject which the speaker made in his "Protected Princes of India." Professor West-

lake, in his "Principles of International Law," would not admit that the native States were semi-sovereign in the eye of international law, because they had no sort of foreign relations. He wrote: "To international law a State is sovereign which demeans itself as independent; a State is semi-sovereign to the extent of the foreign relations which the degree of its practical dependence allows it; and it is non-existent if no foreign relations are allowed it." Now the speaker is well as Sir Henry Maine knew that by this test the native States of India could have no international existence, for they have not a shred of foreign relations, which are exclusively in the hands of their protector, the British Government. Yet, Sir Henry Maine deliberately labelled them as semi-sovereign States, in respect of those other attributes of a complete set of the rights of sovereignty, which in a greater or less degree they enjoyed. Professor Westlake, by the force of his argument, was compelled to challenge Mr. Lee-Warner's plea for the guarded application of the term sovereign States, and he summed up his conclusion in these terms, at page 224 of his "Principles":—"Their position is intermediate to those of a self-governing colony and of a Crown colony. It is a position of constitutional though not of international semi-sovereignty." Mr. Lee-Warner submitted with respect that that was not Maine's view, and the distinction had a very practical bearing both on the methods of the British Government in dealing with the States, and on the attitude of the public mind towards them. If, as Maine argued, international ideas are to be applied to the intercourse of the paramount power with the protected states, then it follows that within the exercise of the attributes of sovereignty left to the States, their rulers are entitled to the respect and independence which the idea of international law so powerfully secures. They must be treated with either gently by agreement and consent, or, if need be, more roughly by the equivalent of "war," where international law would justify warlike operations; but they are not to be subjected to that constant pressure of law or authority which is called constitutional. The States are, as Maine put it, "foreign territory," beyond the pressure of the great ever-moving constitutional glacier. If the British Government has not got in a particular instance what it sometimes has in a native State, namely, a share of its own in that attribute of sovereignty, which is called internal administration, it must receive what powers it wants, as, for instance, a concession of railway jurisdiction, from the ruler of that State by delegation or transfer. It cannot take it by the constitutional method of enacting a law of its own. Another consequence follows from this fundamental distinction. The public mind, however impatient of reform, recognises that foreign territory is over the boundary of its reforming playground. Mental associations are often more powerful than logic, and the best defence of the native States against the pressure of reformers, or people fond of setting others right, lies in the public

recognition of the fact that the States are semi-sovereignities entitled to their own systems of home government. Mr. Tupper had not sufficiently dwelt, in his opinion, on this international conception in Maine's theory of divisible sovereignties, and this had led him into what the speaker must regard as a mistake, namely, the remark that the British political system was a strengthened system built on Mohammedan foundations. The two systems were as wide apart as the extremes of constitutional and international ideas could set them. In Akbar's fifteen provinces, or *subahs* of the empire, the native States were engulfed, and treated as provincial subdivisions. In the Indian Empire of to-day the native States were separated from the British provinces, and the wall of their separation was their semi-sovereignty.

Professor Sir FREDERICK POLLOCK, Bart., said it was particularly opportune that Mr. Tupper, speaking to such an audience, should have called attention to an aspect of Sir Henry Maine's character which must be to a great extent hidden from those who only knew him by his books published in England. He referred to the great practical wisdom displayed in everything Maine did, and perhaps also in several things he refrained from doing. It was only personal intercourse which could quite convince one of the element in Maine's character, that sense of the fitness of things by which he knew instinctively what would do and what would not do. It always seemed to the speaker that that sense was very strongly developed in Sir Henry Maine, and it was all the more striking in a man of his great speculative and intellectual ability. It was not at all uncommon for men of more than considerable intellect to be almost destitute of practical wisdom; nor was it uncommon to meet with great practical wisdom in men not learned, and sometimes positively defective in the power of expressing themselves. In Maine there was a singular union of speculative power and facility of expression with the practical wisdom which kept him out of mistakes and enabled him to keep other people out of them. If a clever and unwise man, armed with Maine's book on Ancient Law, had been turned loose in the Legislative Department in Calcutta, he might have done a good deal of mischief in less than seven years; but being a wise man, being master of his own ideas, not enslaved by them, and having the power of abstaining from making formulæ out of season, Maine did the work not only of a brilliant man but of a great practical statesman. This was an aspect of his work not easily realised by those who had not paid much attention to the government of India. They were all indebted to Mr. Tupper for bringing that forward, and he was especially so, being Maine's disciple, and in such measure as might be, his successor. They were also obliged to Mr. Tupper for having shown the enormous complexity of the task Maine had to face, and which he had much lightened for his successors—the task of governing a country which was living in several centuries at once. If the Presidency towns were living

in the late 19th century, a good deal of the North-West might be said to be still developed in the Mogul period of the 16th century; the Rajpoot States were in the period of the late Middle Ages, and Peshawur, so far as the speaker had been able to ascertain in a very short visit, was about in the state of the early Anglo-Norman period. The Frontier Regulations, on which Mr. Tupper commented, roughly corresponded to the measures taken at Chester, which in the 11th century was a border city, to protect it against the wild Welsh, by putting the inhabitants under the king's peace. It was a happy thing that Maine's historical genius, combined with that practical sense which was so obvious to all who knew him, was forthcoming to grapple with these problems, and if the work of the Legislative Department had looked less imposing since the days of Maine and Stephen, it was really because they, to use a familiar expression, had broken the neck of the work.

Sir ALFRED COMYNS LYALL, G.C.I.E., K.C.B., said in England Sir Henry Maine was chiefly known as a great jurist, a brilliant lecturer, a writer on ancient law, and an investigator of the growth and descent of custom; but he had not been so well known as an Indian legislator and adviser on Indian administration, and, therefore, this paper would be of great use. Maine came out to India at a peculiar time, in 1862, when the great earthquake of the sepoy mutiny was still vibrating, when the demolition which it had caused had left the ground clear, and the work of reconstruction was just beginning. He found himself in the position of a man who had to adjust the mechanism of a great European Government to the habits and feelings of an antique society. If there was anything an Englishman had faith in, it was his political institutions. In India there were none at all, for we had inherited the system of the Mogul empire, which was carried on without any. Another thing an Englishman had great faith in was written law. Many people thought the whole administration of justice depended on written law, but up to the period of British rule he might say that such a thing as written law had never been known at all in India. Then came the period of reform, and Maine stood between two opposing influences. First, you had the advanced reformer, English or native, who thought India wanted institutions, and what occurred to him was to take facsimiles of British institutions and put them down ready made in India, whereby he saved himself a great deal of trouble, and generally got great credit for his magnanimity in giving equal rights to everybody. On the other side, there were the old-fashioned Indian officials who did not want any change at all, or looked upon it with great suspicion, and in this they were backed up by the solid, though silent, support of the whole native conservative society in India. Maine did his work with extraordinary success; he stood between ancient and modern ideas—between the opinions of Europe and India, and had to find a *modus vivendi* that reconciled both. That was the essence of his

work. He did not think Maine made so many original discoveries as had been supposed. Other people had the facts, and knew what they wanted to do, but they did not know how to do it, nor how to justify it; but, when they produced their case, Maine found exactly the formula which explained everything. If you put before him a set of facts, or a certain number of ideas and suggestions, which most Anglo-Indians had stumbled upon in a confused, unfinished way, he would suddenly set them all in order by one of his lucid and wide generalisations, and they discovered that they had been right all along. Maine showed how to do what they wanted to do, and showed its connection with what went before and what was to follow. Another point he might mention was the extraordinary humour of some of Maine's observations. On one occasion, when some English officer had been declaring that he did not like so many laws and rules, he wanted a patriarchal system, Maine said that what the Englishman really meant was not to restore the head of the tribe or family, he meant to be the patriarch himself. Another remark was to the effect that in India land was the basis of society, and every 15 or 20 years a number of gentlemen, whom it would not be disrespectful to call very young gentlemen, wished to come in with a land revenue settlement and reconstruct the basis of society, and that he objected to. His speeches were full of such incisive, pungent remarks; they struck into a fallacy or exaggeration and killed it, and you got the pure light of reason and reasonableness.

Sir COURTENAY ILBERT, K.C.S.I., said his only excuse for taking up the time of the meeting was that he had held in India the office which Sir Henry Maine had adorned, and that he was deeply indebted to Sir Henry Maine during his term of office for wise and kindly counsel. He would group the services Sir Henry Maine had rendered to India under four or five heads, all of which had been touched upon by Mr. Tupper. First of all he tidied over the transition period between the India of the Company and the India of the Queen. Next he framed and passed a great number of important and useful measures; amongst them one of the great codifying Acts, and as Sir Frederick Pollock had pointed out, he abstained from passing a great many measures of doubtful utility. Next, he founded the Legislative Department of India. The foundation of the department was due to a Minute he wrote in 1869, and it was owing to the establishment of that department that his successors were able to carry on the threefold work of codifying Indian law, expurgating the Statute-book of obsolete material, and consolidating its contents. Then in a series of masterly Minutes he based on scientific and intelligible principles the rules which governed the relations between the Government of India and the native States. The tendency of the Anglo-Indian official was to deny that the rules of European international law had any application at all to these relations; the tendency of the Anglo-

Indian lawyer was to apply those rules without always remembering the circumstances under which they were framed. Sir Henry Maine steered a middle course. No one was more strenuous in maintaining the eternal principles of justice and humanity on which international law was based, but he never forgot the wide difference between the East and West, between independent States and States which form subordinate parts of the organisation of a great Empire. Lastly, they ought not to forget the sixteen years, almost, of Sir Henry's life, from his return from India until the time of his untimely death, during which he was the confidential and trusted adviser of the Secretary of State. As to Sir Henry's services to India as a writer, first of all it ought to be said that he was the greatest interpreter of India, not only to the English, but to the whole Western world. Many books had been written about India, but most of them were unreadable. In too many cases the contents—often valuable contents—were veiled and obscured by the employment of crabbed and technical language, and by the writer's inability to appreciate the strangeness and unfamiliarity of Indian phenomena to the Western mind. Sir Henry Maine's genius divined the essential principles of Indian institutions, and he clothed his description of them in the language of consummate literary art. His mind seemed like a sun shooting forth rays of light which bridged over great intervals of space and time, which brought Indian village communities into relation with village communities in Russia, and associated Rajpootana society to-day with the society of the Homeric age. His writings were luminous, stimulating, suggestive. He taught men what to look for and how to observe, and in that respect his work seemed to bear comparison in the domain of legal and political science with the work of Charles Darwin in the domain of natural science. Just as to the student of Darwin the commonest wayside flower was something more than a yellow primrose, and suggested by its structure and mode of life relations to the whole animated world, so to the student of Sir Henry Maine the most ordinary phenomena of Indian social life were brought into organic relation with the world-wide evolution of legal and institutional ideas. In this way it might be fairly said that Sir Henry Maine had changed the attitude of the English mind to the world of India from an attitude of indifference to one of sympathetic insight, and by so doing he had materially facilitated that terribly difficult task of governing with justice and equity the greatest dependency the world had ever seen.

Mr. G. LAURENCE GOMME said a great deal of jealousy would be felt by Englishmen that so much had been claimed for Sir Henry Maine on behalf of India. In England they were so much accustomed to look upon Sir Henry Maine's influence as being distinctly English that it came as a surprise to hear that his influence was so great in India. There was one criticism that he wished to make on the paper,

and that was that before Sir Henry Maine went out to India almost all those who were sent out there were under the influence of the school of John Austin; but Sir Henry Maine's work in India would have been impossible unless he had first examined into that system, and found that it was inapplicable to that country. He should like to call Mr. Tupper's attention particularly to that point. When they tried to estimate Sir Henry Maine's influence upon themselves they would very soon come to the opinion that that question of sovereignty which Mr. Tupper had drawn attention to was one which they in England would have to consider in the great work that was before them in municipalising their institutions. The paper read that evening would be of great service to those who had worked in Sir Henry Maine's spirit for many years, and as a humble student of his, and one who had been personally assisted by him while in England, he wished to say how very much he had enjoyed this tribute, though a late one, to his memory.

Lieut.-Gen. Sir RICHARD STRACHEY, G.C.S.I., F.R.S., said he had been associated with Sir Henry Maine during his Indian career longer than any one in that room. Having been so associated with him, and on terms of close personal intimacy, he could say that he regarded him as having the most brilliant intellect of any man he had ever come across; his influence was always admirable, and his high intelligence in reality permeated and operated in guiding, controlling, and stimulating the active administration of India, and was felt in a great many departments with which he was not specifically concerned, and to which no allusion had been made in the paper that has been read, or the remarks of other speakers.

Lord SHAND said he felt himself somewhat of an intruder on that occasion, as he could not claim either to have been in India or to have had any personal acquaintance with the eminent jurist, administrator, and author, of whom they had been speaking. But he had had many Indian friends, and his acquaintance with them had led him to regret that he never had the opportunity of being in India, for he found invariably that they had the most delightful reminiscences and associations with that country, and he envied them always when he found a number of them together talking over old days and past experiences. He now had some connection with India, because he sat with Sir Richard Couch, Lord Hobhouse, and others in the Privy Council, to deal with Indian cases, but he must confess that with every desire to take a deep interest in the questions of Indian adoption and succession, and in Indian idols and the like, that came before him, he had very great difficulty in becoming enthusiastic; he simply sat at the feet of others and sought to apply those general principles with which he was more familiar, when opportunity occurred. Sir Henry Maine's character had been discussed by gentlemen

thoroughly qualified to do so, and having read the work of his old and valued friend who occupied the chair, and heard all that had been said, he was struck with the extraordinary amount of work which Sir Henry had been able to perform. His health for many years was but feeble, and it was amazing to see not only the extent of the work he got through, but, besides this, his remarkable versatility, for, in almost every department whether as adviser, teacher, administrator, or legislator, he seemed to have stood above all who came in contact with him.

Mr. TUPPER, in reply, expressed his gratification at the discussion the paper had given rise to. He was especially obliged to Sir Courtenay Ilbert, because he had put various points with a clearness and eloquence which he (Mr. Tupper) envied. He concurred with the general drift of Mr. Lee-Warner's remarks. He entirely agreed with Mr. Gomme, in that if Sir Henry Maine had not cleared the way by removing the block of the Austinian jurisprudence he could not have advanced the science as he did.

Mr. G. NOBLE TAYLOR writes:—I had the honour of being a colleague of Sir Henry Maine in the Viceroy's Council for a period of four or five years, and I am able to state from personal experience that the consummate ability, indeed genius, with which Maine dealt with every measure before the Council, to whatever department it related, won the admiration of all who were associated with him, as well as of the general public. While in India, which treated him on the whole fairly well on the score of health, Maine identified himself with the country and the people, and in all his legislation, as shown by his published minutes and speeches, he was careful to avoid any unnecessary interference with the habits and beliefs of the natives. An interesting incident occurred recently on the frontier illustrating this feeling of deference to native religious prejudices. During a lull in the daily fighting a number of troops (of Sir Bindon Blood's force, I think) were scouring the region in search, probably, of a favourable spot where to pass the night. Suddenly there came in sight, in the near distance, a specially sacred Mohammedan shrine, well known, of course, to all the hill tribes and to the Mussulman sepoys of our army; the General immediately gave the order prohibiting British soldiers to approach the shrine, and allowed the Mussulman troopers of the Guides cavalry to ride up to the mosque, where they dismounted, and stood and knelt praying to Allah side by side with Afridis and other tribesmen, against whom they had been fighting furiously a day or two before. It has been well said that one of the best features of the Government of India, from the days of the East India Company until now, is the deference shown at all times to native feeling in religious matters, and it is impossible to over-estimate its good effect and its force in the Empire. This deference was never relaxed during the time Sir H. Maine was a

member of the Government of India. In Chairman's delightful memoir of Sir H. Maine there is a quotation from an article of his, written in the *Saturday Review* in December, 1857, the year of the Mutiny, after which India passed from the Company to the Crown. His vindication of the Company—whom I myself served for 17 years—must be thought admirable. He felt no doubt, as most of us do, that the time had come for the change, but he resented the unjust abuse of the retiring rulers. This is what he wrote:—"The 'antique traditions,' which they have been sneeringly called, of the East India Company, what are they?—Conquest and Government. It is impossible to reflect without emotion on the extinction of so mighty a name. *In hoc signo vinces*. That wonderful succession of events which has brought the youngest civilisation of the world to instruct and correct the oldest, which has reunited those wings of the Indo-European race which separated in the far infancy of time, to work out the strangely different missions, which has avenged the miscarriage of the Crusades by placing the foot of the most fervently believing of Christian nations on the neck of the mightiest of Mohammedan dynasties, will inevitably be read by posterity as the work not of England, but of the English East India Company."

Mr. B. H. BADEN-POWELL, C.I.E., writes:—Mr. I say that the paper appears to be most admirable in that it sums up Sir H. Maine's work not only regards land customs and early law, but also regards the Indian legislation of his time in a manner which is not only strikingly clear and just, but which will be altogether new to many hearers. Equally important is the recognition, I believe now for the first time made, of our great debt to Sir H. Maine's connection with the development of the State policy regarding the "Protected States"—such as those of Kathiawar (in that limited tract there are 187 of them!). There is, however, one point on which I should like to be permitted to say something, because my own attempt to make some contribution to the knowledge of Indian village communities, as they actually are constituted, has led me to differ from the conclusions arrived at by Sir H. Maine—in some respects; and still more to object to deduction from, or expansions of, the theory made by late writers. As far as such divergence might prejudice inquirers against further looking into the facts of village-history, or listening to any argument on the subject, it would be matter for regret if I were misunderstood. The distinguished author of "Ancient Law" could only build his conclusions on the basis of such information as was available at the time; and it is hardly possible not to see that before 1870 the materials for the study of Indian villages not only in the country north of the Vindhyan hills, but (what is even more important) in that to the south of the Ganges was extremely scanty. Sir H. Maine, of course, had no opportunity for "camping out" and person

quiry on the spot; he was dependent on what was record. I have only just had an opportunity of seeing a number of the first series of North-West Provinces' Reports (from 1840), and it is certainly true they contain (merely as far as village-forms are concerned) the minimum of information; and what there is under the blight of that misleading and fortunate classification of North-Western villages which was adopted by the revenue authorities on purely official and practical grounds when nothing better was at hand. As to the Punjab, the frontier villages—of so much importance—were not then described; and although some of the earlier settlement reports do give valuable information about the villages, they are not comparable (in this respect) with the studies made since (say) 1872. Madras, Bombay, and even the Central Provinces were during the same period almost unknown countries, so far as village land-tenures were concerned. Sir Maine himself would have been the last to object to any modification of his theory, or to reject any ascertainment and sifting of facts. And, even if his conclusions had to be abandoned more completely than is actually the case, the value and importance of his work would not really be diminished. The principles on which he went to work, no less than the candid and balanced judgment which corrected his generalisations or suggested conclusions, could never cease to be instructive. Nor could the subsequent reports have been written, or the inquiries conducted aright, if it had not been for the guidance—I say, the inspiration—of Sir H. Maine's spirit and method. When an artist arises with a new creative intelligence, and with a new sense of form and proportion, his work is not the less permanent or definitive because the material which he has to build on or to work on is not yet of the best quality or temper. Succeeding artists, who have a finer silver or silver instead of clay—will be indeed fortunate if they can make, out of the nobler material, something half so good as what the master made out of the less perfect: and they will still remain in his debt for making their art possible. There is only one thing more. The author of this excellent paper has more than once alluded to the tendency of our customs and institutions to perish, under the inevitable, but unwilling, action of Western ideas and progress. May I then take this opportunity to add more to raise the plea for something to be done in India to preserve a better record of the old forms and constitutions of North Indian joint-families? These original forms are fast becoming obscured by the effects of partition, &c., and by their being shrouded under the most misleading and incomplete present state of our knowledge perfectly adequate classification officially adopted. I have favoured, in a short appendix to chapter viii. of my book on "The Indian Village Community," the merits of the case. The Government of India has done so much in the realm of material history to preserve, measure, photograph, and

reproduce the beautiful remains of Indian antiquity: will they not (when war, plague, and famine give them a little respite) do something to rescue the statistics of North Indian villages from a form of classification which involves a use of terms such that hardly two districts or divisions use or understand them in the same sense, and which (as I have tried to show) engulf, under certain vague general headings, quite a number of really different and interesting forms?

FOURTEENTH ORDINARY MEETING.

Wednesday, March 16, 1898; WILLIAM LUSON THOMAS, Member of the Council, in the chair.

The following candidates were balloted for and duly elected Members of the Society:—

Alward, George Lowe, 11, Hainton-street, Grimsby.
Barrington - Baker, Lieut.-Colonel Robert, Royal Naval Ordnance Depot, Plymouth.

Bowman, Rev. Arthur H., 48, Foxgrove-road, Beckenham, Kent.

Edmonds, Frederic Bernard, 6, Clement's-inn, W.C.
Grice, Walter T., 9, Dalhousie-square, Calcutta, India.

The following candidates were proposed for election as members of the Society:—

Clarke, Philip Hamilton, 223, The Grove, Hammer-smith, W.

Davenport, Cyril James, The British Museum, W.C.

Pitt, Walter, Grove-lodge, Lansdown, Bath.

Read, Harry V. Rudston, Hyde-park-court, S.W.

Whinfield, Edward Henry, M.A., St. Margaret's, Beulah-hill, Norwood, S.E.

The paper read was—

THE RECENT HISTORY OF PAPER MAKING.

BY CLAYTON BEADLE.

This year is eventful as being the centenary of Nicolas Louis Robert's great discovery. It was in 1798 that Robert conceived the idea of making paper by means of an endless wire machine. Robert's discovery gradually brought about a complete revolution in the manufacture of paper. It is my intention to trace briefly some of the more important changes that have taken place since that time. It is impossible within the scope of this paper to give more than a very brief description of a few of the changes that have taken place, and therefore I do not attempt fully to go into technical details.

SCARCITY OF RAW MATERIALS 100 YEARS AGO.

From time immemorial and up to the time of Robert's discovery, all paper had been made by hand on a hand-mould. All white papers were made from cotton and linen, and rags constituted practically the only source of supplies. Rags were becoming rapidly more scarce, and to add to the dilemma the demand for paper was rapidly increasing. The scarcity of rags was popularly ascribed to the use of rags as "lint" in the European wars. In order to safeguard the paper-makers of this country Parliament had prohibited the burial of the dead in linen and cotton shrouds, and enacted that rags and old nets (which were used for the manufacture of paste-boards, wrappers, and packing-paper) should be imported duty free. It likewise allowed the free importation of all waste paper, provided that it was torn to pieces, and used for nothing but remanufacture. In spite of this encouragement given by the Government, many of the mills in this country at the end of the last century were shut down for want of supplies.

EARLY TREATMENT OF RAGS.

The Cleansing Process.—The rags when received at the paper-mill were cut up and sprinkled with water, and made into a heap upon the floor. This treatment caused the rags to heat and ferment. The mass was turned occasionally to prevent over-heating. This primitive process oxidised and rendered soluble the waxy, gummy, and resinous constituents associated with the fibre. We have good reason to believe, however, that the fibres were very much weakened. The fermentation took weeks and sometimes months to complete its action.

Boiling in Open Pans.—The foregoing process, which is sometimes described as "retting," or more correctly as rotting, was superseded by a scald in an open pan or copper, which in early times was heated by a live fire underneath. Sometimes quicklime, or the ashes of plants, were added for the removal of the grease. A fire in direct contact with the copper necessitated a large amount of solution to keep the rags afloat, or else constant agitation to obtain a uniform temperature, and prevent the mass from charring at the bottom. About the end of the last century a chemist named Leblanc devised a method for the manufacture of alkali, which had previously been derived from natural deposits or the ashes of plants.

Low Pressure Kiers.—Next we have use of low pressure kiers, as described by Sir John Evans in his presidential address before the Society of Chemical Industry in 1893.

Pressure Boilers Cylindrical and Spherical.—In order to promote a more uniform circulation of the boiling liquor, revolving boilers were used, and to make the chemical process more economical and thorough steam pressure was increased from 30 to 50 lbs. to square inch. Sometimes the boilers were cylindrical, as those made by Bryan Donkin and Co., and sometimes spherical, as those now present made by William Lord. The latter are generally preferred in consequence of being much more easy to empty. Caustic soda liquor is now chiefly used for boiling rags, but sometimes sodium carbonate and lime are added together, and for certain classes of rags lime alone is still used. Within recent years the boiling of rags has been made the subject of close and systematic study, which has resulted in a better and more economical treatment.

THE MATHER KIER FOR BOILING RAGS.

When treating large quantities of rags the "Mather Kier" made by Messrs. Mather and Platt, of Manchester, is more economical than a cylindrical or spherical boiler (Fig. 1). A Mather Kier 8 feet long by 7 feet diameter, is adapted to treat two trucks, each capable of containing 10 tons of rags. The running of the trucks into the kier and closing of the patent door only occupies about three minutes. The rags are then saturated with 750 gallons of caustic soda solution, which is kept in continuous circulation by means of a centrifugal pump. Within 10 minutes the pressure has reached its maximum, i.e., 10 lbs. per square inch. The boiling is continued for from one to two hours. The liquor can be blown off in 15 minutes without any cooling, the door raised, the trucks removed, and a fresh lot run in. The rags are now washed by allowing water to percolate through and replace the alkaline liquor. The liquor can be removed, if desired, without dilution. The proportion of liquor to weight of rags is much lower than in the revolving boiler, consequently the amount of fuel and soda required per ton of rags is less. The time required for boiling is about one hour and the water required for washing about one-fifth. The output of a Mather kier 7 feet diameter by 8 feet long is 25 tons a week, whereas it would require three revolving kiers

the same capacity to treat the same quantity.
Mather kiel is more particularly adapted

The cleansing of rags has become a more complicated problem in consequence of the

FIG. 1.



halls where large quantities of rags are
and.

great variety of qualities, each of which requires
its own special treatment.

CLEANSING OF NEW RAGS.

Rags known as "new pieces," which contain a large amount of starch, cannot be cleansed like ordinary rags. The starch, instead of being dissolved and removed by caustic alkali, as one would expect, is in presence of the other foreign matter, converted into a brown slimy mass, or into hard and horny particles, which do damage in the after processes. For the removal of the starch it is generally customary to boil first in hot water, to drain off, and then to boil under pressure in a weak solution of caustic soda. This process is far from satisfactory, in consequence of starch forming with cotton and linen fibres a compound known as "starch-cellulose," from which the starch cannot be removed by boiling water. Mr. C. F. Cross suggested the use of malt extract, and about six years ago I was associated with him in working this on a large scale. The process has been in regular operation since it was first started. The amount of malt necessary varies from $1\frac{1}{2}$ to 3 lbs. per 100 lbs. of rags, according to the amount of starch they contain. The malt is saturated with water, which should have a temperature of 150° Fahr. in summer, and 170° Fahr. in winter. It is allowed to soak for two hours, drained off, and filled with hot water, which is shortly drawn off and mixed with the first draft. The malting of the rags is done either in a rotary boiler or a kier. The malt liquor is introduced into the boiler, together with sufficient water at 80° Fahr. to keep the rags saturated. From one to two hours is sufficient for the conversion of the starch into dextrine and maltose. The rags are then washed with hot water.

SUN BLEACHING.

In the early days when rags were fermented to cleanse them from grease and dirt, bleaching liquids were not known. Our forefathers made use of the only bleaching agent they had, viz., the sun's rays. The washed rags were spread out on grass in the sun, and occasionally turned and sprinkled with water. The process must have been exceedingly long and laborious, and the final result very uncertain, being dependent upon a proper amount of sunshine, and upon the actinic rays of the sun, which vary so much at different seasons of the year. At that time the processes of cleansing and bleaching must have taken as many weeks as our modern processes do hours. Sun bleaching (or grass bleaching as it is sometimes called) had, however, one redeeming feature—it did not injure the fibre.

Chlorine was discovered by Scheele in 1774 and was used for bleaching in 1787. Hypo-chlorite of lime or bleaching powder was first used by Tennant in 1799.

BLEACHING WITH CHLORINE GAS

Chlorine gas appears to have been first applied as a bleaching agent. The rags, called "half-stuff" were placed in stone chambers, and the chlorine generated in stone retorts. This process, although effective, was very cumbersome, and by no means pleasant, on account of the escape of chlorine gas into the surrounding atmosphere. In spite of these difficulties of this process, it died hard; it was in use for a great many years, and long before the use of bleaching powder was established among paper-makers. Chlorine bleaching is still practised for certain purposes. Chlorine is rapid in its action, and, of course, has the advantage over bleaching powder in that it does not add lime salts to the fibre.

BLEACHING POWDER.

Tumbler Bleaching.—The first application of bleaching powder to rags, I believe, was what is known as tumbler bleaching. The tumbler was very similar in construction to a revolving cylindrical boiler. As it was not required to stand much pressure, it was made of cast-iron. It was lined with lead to protect the iron against the action of chlorine gas. The tumbler was partly filled with water, and the rags, which were covered with water. To this was added a clear solution of bleaching powder and vitriol, and the man-hole immediately fastened on. The tumbler was made to revolve slowly for about 12 hours. The bleaching agent in this case was not calcium hypo-chlorite, but hypo-chloritic acid, which was freed by the action of vitriol. When the bleaching was complete, the liquor was drawn off and the tumbler discharged.

BLEACHING IN THE ENGINE.

Bleaching powder is now added either to the poacher or the beating-engine. When added to the beating-engine—to the beaten or partly beaten stuff—the excess of hypo-chlorite is to be killed by the addition of some "antichlor." Formerly, sodium thiosulphate (commonly known as "hypo" among photographers) was used. This substance, although the cheapest "antichlor," has been for the most part abandoned, in consequence of the formation of hydrochloric acid with the residue of bleach, which played havoc with the fibre.

the paper machine. The "antichlor" in common use at the present time is sodium hypochlorite. Although it is more expensive than "hypo," it is cheaper in the end to use it, in consequence of the saving to the fittings of the paper machine.

BLEACHING IN STEEPING TANKS.

The best and most universal method of bleaching rag-stuff is to add a bleaching solution to the "breaker" or the "poacher." The rag "half-stuff" is generally heated with steam jet to accelerate the bleaching action. After a few hours' action, the bleach is either washed out in the poacher or the half-stuff is put into "steeping" tanks, and after the chlorine has exhausted itself upon the fibre, the stuff is drained and dug out and removed to the beater. A better method of getting rid of the liquor is to pass the half-stuff over a *essse-pâte*.

PERMANGANATE BLEACHING.

Several attempts have been made to utilise potassium permanganate and sodium manganate as bleaching agents. Both these substances, when added to rag half-stuff, liberate bleaching oxygen and coat the fibres with black oxide of manganese. After the addition of sulphurous or sulphuric acid, the black coating is removed, and the fibre is found to be bleached. The action of permanganate is not instantaneous. The process has not been thought much of in consequence of the high price of permanganate. I made a number of trials both on a large and a small scale with this substance. At the time of my trials permanganate was just ten times the cost, weight for weight, of bleaching powder. I found, however, that 1 lb. of permanganate did as much bleaching as 10 lbs. of bleaching powder. The fibres, however, very tenaciously retained a small residue of manganese salts, which caused the finished paper to "go back" to its original colour. From a theoretical point of view, the results are interesting, as showing that the oxygen of permanganate is a more efficient bleaching agent than the oxygen of bleaching powder. In other words, 1 lb. of permanganate generates a much larger quantity of bleaching material than 1 lb. of bleaching-powder oxygen.

ELECTROLYTIC BLEACHING.

Many attempts have been made to utilise electrolysed solutions of the chlorides. Andrioli electrolysed a solution of brine forming sodium hypochlorite. The most promising of these

processes, however, is the Hermite process. Hermite obtained magnesium hypochlorite by electrolysing a solution of magnesium chloride. He claimed that 3 lbs. of chlorine in his solution did as much bleaching as 5 lbs. of chlorine in ordinary bleaching-powder solutions. These claims were substantiated by the results obtained by Professor Pictet and Messrs. C. F. Cross and E. J. Bevan in the bleaching of wood pulp and other fibres. In order to see whether the same held good in the bleaching of rags and rag half-stuff, I conducted a number of trials, both in "steeping tanks" and in a paper-maker's beater. My average figures were in the ratio of 3 lbs. of Hermite chlorine to 4.8 lbs. of bleaching-powder chlorine, thus closely confirming the figures of other observers.

The Hermite solution, besides consuming less chlorine, was also much more rapid in its action than ordinary bleaching powder. From figures given by the proprietors of the process it appears that a great saving could be effected by the adoption of this process, but as far as I am aware, the Hermite process has not been worked with success in any paper mill in this country.

OZONE BLEACHING.

At present there appears little prospect of any bleaching agent displacing bleaching powder. (Of course I put the electrolytic processes for the manufacture of chlorine and caustic soda out of the question, as these do not affect the question of bleaching powder being superseded for paper-making.) If I might venture to prophesy, I should say that a complete change will come some day when we have a cheap and ready method of producing ozone or ozonised air that could be easily worked by paper-makers.

Ozone is an excellent bleaching agent. Its action is very rapid, and there is no chemical residue that can be either injurious to the fibre or to the paper machine.

THE PAPER MACHINE.

During last year several attempts were made to revive the early history of the paper machine. The most important publication on this subject appeared in *The Paper Trade Review*. It contained an account of the invention of the first paper machine and a history of those men whose names should ever be remembered, not only by paper-makers, but also by the whole of the civilised world, for the lasting benefits they have conferred upon us. The men to whom I refer are Robert, Didot, Gamble,

Henry and Sealy Fourdrinier, and Bryan Donkin. I could not do better than refer all those who feel sufficiently interested in the subject, to the above-mentioned publication. I shall endeavour to explain to you as briefly as possible the part which these men played in the invention and development of the paper machine.

NICOLAS LOUIS ROBERT.

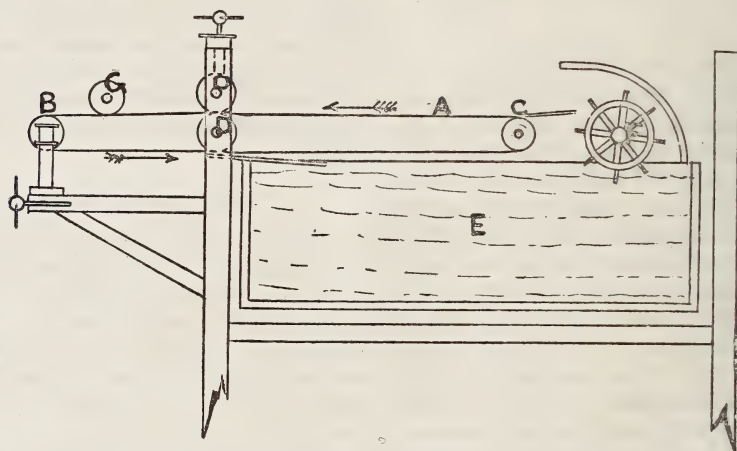
Nicolas Louis Robert was the originator of the paper machine. He was born in Paris in 1761. He entered the French army in 1780, and appears to have seen a good deal of active service in the wars between the North American colonists and the British Government. On obtaining his discharge from the army, he accepted an engagement as proof-

armed with these to England in 1800, apparently with the object of obtaining assistance of English capital, and the operation of English engineers, in bringing the invention to a successful issue. Gamble obtained English patents soon after his arrival. He came in contact with Henry and Sealy Fourdrinier, members of a well-known firm of wholesale stationers. Gamble, after having entered into some arrangement with the Fourdriniers, returned to France, and reported himself to Didot. In 1802, Didot and Gamble came to England with a model of a paper machine.

THE FIRST PAPER MACHINE.

It is useless to attempt to follow the specification of the first paper machine in detail.

FIG. 2.



FIRST PAPER MACHINE.

reader in 1794 to Monsieur Pierre Didot. He soon afterwards entered the service of Monsieur Didot St. Leger, the son of Monsieur Pierre Didot, who had a large paper mill at Essonnes. Robert, while managing this mill, conceived the idea of making paper in a continuous web. He spent about four years experimenting, and at last produced a machine, consisting of an endless wire band passing between two squeezing rolls. In this work Monsieur Didot greatly assisted Robert, placing his machinery, men, and capital at Robert's disposal. Robert transferred his patent rights to Didot.

JOHN GAMBLE AND DIDOT.

John Gamble, Didot's brother-in-law, was an Englishman, and resided in Paris. He was given some sheets of paper of very large size, made on Robert's machine. He came

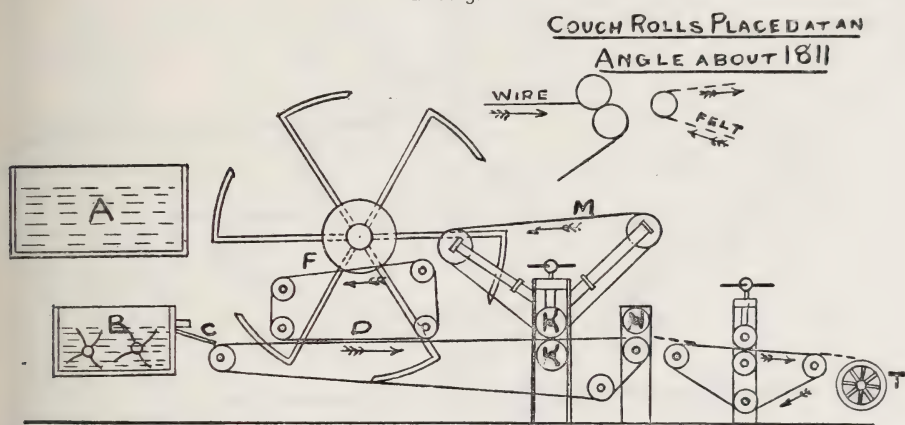
The machine consisted of an endless band of copper wire gauze (A), such as was used for covering the frames of paper moulds. The wire was stretched in a horizontal position between two rollers, B and C. The roller B was fixed to a frame, but B could be moved as to take up any slack in the wire cloth. D, D, wire squeezing rolls, through which the wire cloth passed in the direction of the arrow. The rolls could be adjusted so that they pressed tightly together. The wire cloth extended over a tub, E, containing the beaten pulp. F was a drum provided with fans, which revolved on the surface of the liquid, so as to lift it in a regular stream on to the revolving wire cloth. During the transit of the stuff from roller C to the squeezing rolls, O, a portion of the water passed through the meshes of the wire into the vat; passing through the squeezing rolls, D, a further

quantity of water was removed, and the web of paper was made to adhere to the roll G and reeled upon it until a quantity was obtained, when a new roll was put in its place. A lateral shake was given to the travelling wire in order to imitate as far as possible the shake produced in the hand mould. The wire was so filled with a crude contrivance which did service for a deckle, in forming the edge of the paper. A reel of paper removed from the machine on the roll G was unwound and passed through a "pressing machine," which also formed the subject of a patent. This rendered the paper strong enough to be hung up in a drying loft. Gamble appears to have made use of some of Robert's improvements and to have patented them in his own name when he came to England.

them and was "couched" from these rolls, round which the two wires returned, on to an endless felt. This arrangement did not allow the water to pass away with sufficient freedom, and the web of paper was continually breaking in consequence. Donkin spent a lot of time at Two Waters watching the working of his machine. One day it suddenly occurred to him to place the "couch" rods at an angle instead of vertically one over the other. This very simple alteration made all the difference to the removal of the water, and is generally acknowledged by engineers and paper makers to be one of Donkin's most important discoveries. This change appears to have been made about 1811.

In the *Paper Trade Review* of December 7, 1888, appeared a reproduction of the drawing

FIG. 3.



ORIGINAL FOURDRINIER PAPER MACHINE, A.D. 1808.

THE FOURDRINIERS AND DONKIN.

Messrs. Fourdriniers, who financed the undertaking in England, employed Messrs. Hall and Co., engineers, of Dartford. Halls had in their employ a young man named Bryan Donkin, who showed great interest in the construction of the paper machine. Halls evidently was not particularly anxious to pursue this work, and so ultimately the Fourdriniers bargained for Bryan Donkin's services, and in 1803 premises were taken in Bermondsey (those which are now occupied by Messrs. Bryan Donkin and Co.) where the first fully successful paper machine was built. The machine built at Hall's works appears to have been put in a mill at Dartford. The first machine made in Bermondsey appears to have been sent to Two Waters Mill in Hertfordshire. The latter machine had two endless wire bands, one above the other. The paper passed between

of the original Fourdrinier paper machine supplied by Bryan Donkin and Co., of Bermondsey. This machine was patented in 1807 by Henry Fourdrinier, Sealy Fourdrinier, and John Gamble, and improved and made by Bryan Donkin and Co. in 1808. This machine is a great advance on Robert's first machine. There is a separate stuff chest, A, on a high level communicating with a wooden vat, P, provided with agitators, on which the thick stuff is diluted with water, and into which the "back water" from the machine is made to flow.

The stuff flows down an inclined copper plate C on to the travelling wire D. The wire is placed at an incline to prevent the sudden rush of stuff along the wire. The drainings from the wire are caught and conveyed by means of the "back-water lifter" to the wooden vat. A proper deckle, F, travelling with the machine wire, is used.

To get rid of some of the surplus water, a pair of squeezing-rolls, K, are used close to the "couch" roll. Round the top roll is an endless web of felt or wire gauze, M. The paper passes from the "couch" roll, N, on to an endless web-felt, and through a pair of steel press rolls, and is finally reeled on a drum at T.

DIDOT'S MOULD-CHAIN MACHINE.

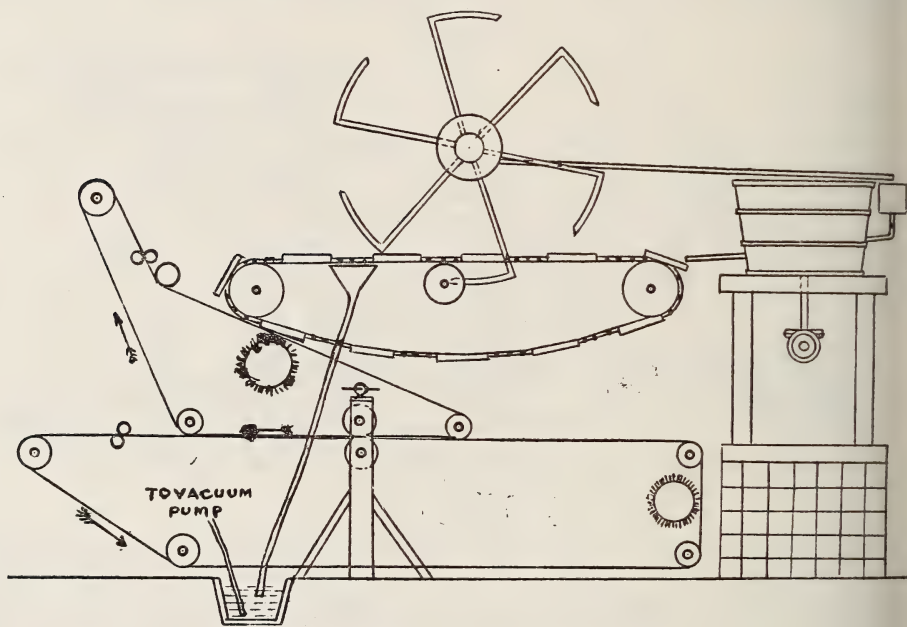
In 1812 Didot constructed a machine on what he called his mould-chain system. This machine made sheets of paper by moulds attached to one another by means of links in such a way as to form a travelling band as in the Fourdrinier machine. This machine was

A device was used for keeping the web straight and tight, that has only within the last few years been abandoned. Top and bottom wet-felts were used, and revolving brushes, and a flow of water in contact with the felts to keep them clean.

FOURDRINIER'S BANKRUPTCY.

Up to the year 1807 the Fourdriniers spent over £60,000 in experimenting with and improving the paper machine. They had been compelled to neglect their stationery business, and in 1809 they sustained a loss in the business of £5,635 in consequence. "A commission in bankruptcy was accordingly issued on November 8, 1810, under which Mr. Charles

FIG. 4.



DIDOT'S MOULD CHAIN MACHINE, A.D. 1812.

exceedingly complex in comparison with its predecessors. It was also a step in the wrong direction, as it produced only sheets of paper instead of an endless web of paper. It is very important, however, as embodying many improvements that have survived to this day. The stuff-chest was similar in construction, and provided with a similar agitator to that used at present.

The mode of producing the shake by means of a revolving disc, enabling the machine-man to alter the length of the shake at will, is a decided step in advance. Apparently for the first time a vacuum was applied to the under side of the wire to drain off the surplus water.

J. Bloxam (a son of their former partner) and another person were appointed assignee on behalf of the unfortunate bankrupts. . . . So the storm burst, and when it had passed Henry and Sealy Fourdrinier, Saint Louis Didot, Nicolas Louis Robert, and John Gamble were ruined and disappointed men." *

The story of the final careers of these men is a long and very sad one. We few can know how much we are indebted, as a nation, to the labours of these men.

The Fourdriniers, in spite of their financial difficulties, struggled on, and after a long trouble succeeded in obtaining an extension

* *The Paper Trade Review*, November 6, 1891

their patent to the year 1822. The story of Fourdrinier's attempt to obtain royalties from the Emperor Nicolas is a proof of his energy.* The Fourdriniers became involved in a number of law suits with their agents, through which they sustained a loss.

In 1836 a petition was presented to Parliament, which resulted in the appointment of a Select Committee of Commons for the purpose of inquiring into the advisability of compensating the Fourdriniers, or further extending the life of their patent. The Committee, in its report, strongly recommended the claims of the Fourdriniers to the consideration of Parliament, and £20,000 was talked of as a compensation. Finally it appears that a sum of £7,000 was awarded the Fourdriniers by the Government in 1840.†

In 1814, when some dozen machines had been constructed on a new principle, and machine-made paper was becoming fairly well known, the Emperor Alexander I. of Russia, whose dominions had then just recovered from the ravages of 1812, came over to England for the Peace Congress and heard of the invention. He appears to have commissioned one Wistinghausen (though this was afterwards officially denied, the transaction being construed as a deal one between this individual and H. Fourdrinier), to induce the inventors with a view to the apparatus being sent into Russia. Accordingly an agreement was entered up, under which Henry Fourdrinier agreed to permit the use of two of his new machines (which were erected under the patronage of one of his sons) in the Imperial Paper Works at Peterhof for ten years, at a royalty of £700 per annum.

The agreement further provided that Fourdrinier was to be free from time to time to communicate, free of charge, to the Russian Government, all improvements that might be made. In pursuance of this latter clause, one of his sons went to St. Petersburg in 1824 to give details of something that had been added in the meantime, although not a portion of the stipulated £7,000 had then been paid. Nor was the debt ever discharged. Years of correspondence proved fruitless, Henry Fourdrinier, though then in his prime, went to St. Petersburg himself and laid his case before the British Ambassador, who approached the Russian Government on the subject. No satisfaction was obtained, Fourdrinier, not to be daunted, penetrated into the grounds of the Imperial Paper Works in June, 1843, and presented the Emperor (Nicholas) with a petition setting forth his claims. This proved as void as all his other efforts to get payment, and after a long delay, no answer being received, he left St. Petersburg in disgust, but not despair. For, as a writer of the time said, "the will that, through years of patient toil, struggled against mechanical difficulties, and finally overcame them, was not to be arrested by any obstacle." After the Emperor Nicholas visited London, and he was again approached by Fourdrinier, but, alas, again without result. His pertinacity may be accounted for by the fact, in his impecunious condition, the payment of this debt would have been a very great advantage to him.—*Paper Review*, November 26, 1897.

It was felt that some recompense was due to the brothers, and Scaly, in recognition of the signal services they had rendered to the trade and to the country. So in 1836, as the result of an influential petition, suggesting either a renewal of the patent, a House of Commons was appointed to collect evidence and investigate

Bryan Donkin was the only one of the six pioneers who made anything out of the invention of the paper machine. His firm produced from 1803 to 1812 10 machines, from 1813 to 1822 25 machines, and by the year 1851 they had produced 191 machines.*

the matter fully. It met in May, 1837, and was under the chairmanship of Mr. Mackinnon, a gentleman who, although previously an entire stranger to the claimants, was so far impressed by their condition and by the justice of their cause that for years after he consistently advocated the matter in Parliament. A report was prepared, recommending the claim to the favourable consideration of the Government, and it was understood that £20,000 was talked of as a reasonable sum to grant. When the report was presented to the House the Speaker took exception to it, because the word "compensation" occurred in it, for which he said there was no precedent, though it was afterwards pointed out that this opinion was erroneous. Then the matter slumbered for a couple of years, although one of the Chancellors of the Exchequer of that day seems to have thought that £15,000 might reasonably be granted to the Fourdriniers. As the Government appeared reluctant to do anything of themselves, Mr. Mackinnon, in the spring of 1839, moved in the House that some definite action be taken upon the report of 1837. Some debate ensued, and Sir Robert Peel said that if the Government's hands were not forced, they would do full justice to the case. One speaker referred to the fact that, although the Fourdriniers were not the original inventors of the machine, yet it had been brought by them to such a degree of perfection as to enable the public to benefit by the discovery. The opinions of Brunel, the celebrated engineer, and Mr. Lawson, of the *Times*, were also quoted, to the effect that the invention "was one of the most splendid of the present age." The inventors had been ruined by their invention, and the general opinion seemed to be that something substantial should be done for them. Ultimately, however, in deference to the expressed wishes of the Government, the motion was withdrawn. Another year passed by, and then a grant of £7,000 appeared in the Supply estimates for the current financial year. The vote was discussed in the House of Commons on the 8th of May, 1840. The Chancellor of the Exchequer, in proposing it, said that he had great hesitation in proposing anything, as such a course might tend to encourage other disappointed inventors to look to the Government to recoup their expenses, rather than to their own efforts. Further, the Fourdriniers were not the original inventors, nor ever the original patentees, the latter being Gamble, who had sold his patent to the brothers, and "to neither belonged the merit of having perfected the invention." In any case, £7,000 was quite enough for the improvers of a patent. If more were thought needful, the trade who had been benefited should find it, and not the country. The sum suggested was felt to be too scanty, and Mr. M. Phillips (who had presented numerous petitions from the public in favour of an increased grant), and several other speakers took the opposite side, pointing out how the Government offices saved £60,000 a year in paper in consequence of the invention; how the Fourdriniers, who had expended £40,000 (*sic*) of their own money in perfecting the patent, had thereby been the means of saving 25 per cent. in the manufacture of paper (the House of Commons alone, it was estimated, saved 10s. a ream in the 20,000 reams required annually for its official documents). But all these weighty arguments went for naught, as the Government set its foot down, saying there were plenty of other equally deserving inventors whom it was not proposed to compensate, it was setting a dangerous precedent, etc., etc. So the vote passed without alteration, and it was said that to get it one of Henry Fourdrinier's sons (? George) had spent no less than £3,000 from first to last.—*The Paper Trade Review*, December 4, 1897.

* Report of the Juries of the Exhibition of 1851.

Messrs. Bryan Donkin, and Co. excelled all other makers of paper machines. They appear to have supplied machines to all civilised countries of the world. Donkin also introduced the revolving boiler for boiling rags under pressure, which was a great improvement over the previous methods of treatment. Some of the boilers made by his firm are in constant use to the present day, and there are few boilers to beat them.

OTHER DISCOVERIES IN CONNECTION WITH THE PAPER MACHINE.

As previously stated, suction pumps were applied to Didot's mould-chain machine in 1812. It was not until 1826 that suction pumps were applied to the Fourdrinier machine by Canson, who kept it a secret for a time, but communicated it to Wise and Middleton in 1832. The method of applying the suction was improved upon subsequently by Brown and Crompton.

Crompton in 1820 took out a patent for "drying and finishing paper by means of cloth or cloths against heated cylinders, and the application of a pair of shears to cut the paper off in continuous lengths as it comes from the machine or rollers."

The "Crompton Dryer" gave a great impetus to the manufacture of machine-made paper. In consequence, however, of the imperfections of the Patent-law of his time some people succeeded in setting aside his patents.

In 1828, Crompton and Taylor obtained a "patent for cutting paper longitudinally by means of revolving circular blades." This method of cutting paper is in common use at the present time.

The following interesting statement appears in the report of the jurors of the Exhibition of 1851:—"Fine writing paper is now made, sized with gelatine, dried, and cut into sheets at the rate of 60 feet a minute in length and 70 inches in width, at the works of Mr. William Joynson, at St. Mary Cray, Kent, which produces from only two machines the large quantity of 25 tons per week." Contrast this with the output of one of our modern machines producing paper. A modern machine will produce a piece of paper 300 to 400 feet long and 120 inches wide in one minute, and will turn out about 55 tons of paper per week. This is about five times the output in weight and five times the speed of a machine in 1851. The best machine in 1810 was run at 30 feet per minute. This is half the speed of a machine in 1851.

Mr. Lines, the foreman at Mr. William Joynson's mill, is generally accredited to the first to "water-mark" machine-made paper. He tried it by sticking some tinned wires on to the "couch" roll by means of soap. However, we find that Thomas Barratt of St. Mary Cray, took out a patent in 1830 inserting the maker's name in machine-made paper. Barratt also produced rolls by a new process with a great degree of accuracy, and it was owing to this that the surface glazing of paper was so much improved. It is probably largely owing to Barratt's efforts that Messrs. Joynson and Son have obtained such a reputation for plate-glazed and highly finished writing paper.

Iboston, in 1830, invented the strainer plate which have been of such service in removing the knots, lumps, and dirt from the pulp, and thus enabling paper-makers to produce clean papers.

The "Dandy-roll" was invented in 1830, by Wilks, a partner in the firm of Bryan Donkin and Company. The Dandy was primarily used to remove some of the surplus water, and to facilitate the "couching" of the stuff; but the "Dandy-roll" now is constructed of wire, and imparts to the surface of the paper the "laid" or "wove" marks. It is also the roll which carries the name or water-mark, which imparts to the paper by making an impression upon it when in a semi-wet condition.

In 1809, Dickinson constructed a machine on quite a different principle to the Fourdrinier machine, for making endless paper. This consisted of a hollow cylinder covered with wire cloth, revolving in a vat of pulp. The cylinder was exhausted from the interior of the cylinder as it revolved, which caused a network of fibres to form on its surface, which was stripped off in the form of an endless sheet of paper. This form of machine, known as the cylinder machine, is in extensive use to the present day for the manufacture of a certain class of papers.

The year of Her Majesty's accession to the Throne was an important one to paper-making. It was in 1837 that an impetus was given to the paper trade of this country by the abolition of one-half of the excise duty on paper. It was not, however, until the year 1861 that the whole of the excise duty was removed, and that year also the import duty on foreign papers.

Mr. Bryan Donkin, junior, informs me that it was not until 1835 or 1837 that the manufacture of continuous lengths of paper was really

accomplished. About that time sheets were made for the first time, a mile or more in length.

PAPER-MACHINE WIRES.

In the manufacture of the paper-machine wires, great progress has been made within recent years.

Under the old system the wire was drawn through steel plates, pierced to suit the diameter of wire wanted. Even in the hands of the most experienced, it was difficult to make the hole perfectly smooth, and while the wire was being drawn, the hole often got slightly enlarged, so that a hank of wire would be a little greater in diameter at the end than at the beginning. Because of this, the wire cloth was more or less rough and irregular, thus causing a very pronounced wire mark on the paper, and irregular wear on the machine.

Now, all wire used for this purpose is drawn by special machinery through diamond or carbon dies, the holes in which are perfectly round and smooth, and as the die is very much harder than the wire drawn through it, absolute accuracy can be relied on for a considerable time, and any irregularity or increase in diameter can be readily detected and rectified.

Machine wires made of wire drawn in this way can be made stronger, and at the same time more smooth and regular than under the old style.

The opinion held by many is that machine wires to-day are not so strong and durable as those woven 30 years ago. That the reverse is the case will be readily conceded when the very different working conditions are kept in mind. Paper machines now carry a very much larger wire, and are run at a greater speed than they were 30 years ago. Different classes of material and stronger chemicals are also employed, and throughout the whole mill things are pushed through at a pace undreamt of at that time.

The true standard of value of a wire is the tonnage of paper produced, and judged on this basis the wires of to-day will much more than hold their own with earlier wires; in fact, the latter would be found to be quite unsuitable for the requirements of modern manufacturing. A case in point may be quoted. In *Paper Making* of January 5, 1897, a well-known firm of paper-machine wire manufacturers—George Christie, Limited, of Glasgow—had an extract from a letter they had received from a continental mill, the mill owners writing as follows:—"It will doubtless be satisfactory

for you to know that the wire which you sent for our large machine has worked nearly four months (119 days), and has produced 600,000 kilos of paper (about 590 tons)."

At the Paper Makers' Exhibition, held in London in June, 1897, the same firm had on exhibit a *presse-pâte* wire which had been on the machine for ten months, during which time the machine ran off 4,515 tons of material.

In fine papers to-day, a very fine finish is insisted on, and without the improvements already referred to, this could not be given.

Messrs. George Christie, Limited, Glasgow, have lately taken out a patent for an attachment to their wire-weaving looms, by means of which the surface of the wire is rendered perfectly smooth and regular, while the cloth can be woven of great weight. In consequence, the wire mark on the under side of the sheet is greatly minimised, and the life of the wire on the machine increased.

When the *presse-pâte* came into use, it was necessary to provide a machine wire that would withstand the action of the bleaching powder contained in the "half-stuff;" this is now done by coating the wire with tin. The tinned wire lasts as many months as the uncoated wire did days.

The utilisation of esparto grass, straw, mechanical and chemical wood pulp for the manufacture of paper, has brought about in recent years a complete revolution. It is entirely outside the scope of this paper to enter into the history of these substances. Wood now forms the chief staple in point of quantity as a paper-making material, and its utilisation is likely to increase in the near future. Undoubtedly, the next generation will be brought face to face with a serious problem. The Board of Forestry in Germany are alive to the necessity of replanting the timber of forests that have been rapidly depleted for the manufacture of wood pulp; but in other countries enormous quantities of timber are being removed from the forests annually without any attempt at replanting. The requirements of the paper trade are likely to become a great drain upon the forests of Scandinavia, the United States, and Canada.

Judging from the present rate of increase, the wood required will, before long, assume enormous proportions. It was estimated a few years ago that in the United States of America alone 500,000,000 cubic feet of timber were consumed annually, representing the destruction of 100,000 acres of forest. It was also estimated that each day the *New York World*

consumed timber equal to seven acres of an average forest. The world's timber suitable for paper-making is not inexhaustible, and we may some day be in a position in regard to wood as this country was at the end of the last century in regard to the supplies of rags.

There has been a great deal said during the last few years about the high speeds of some of the American paper machines. We have heard much about American machines running at 500 feet per minute, but these statements must be taken with the proverbial "grain of salt." If such high speeds have been actually attained it can only be for the purpose of breaking the record. A machine conscientiously constructed to run regularly at this excessively high speed must be of very doubtful economy. The first cost of such a machine must be very great. The wear and tear and depreciation must be very high, and the machine wires and felts must be specially made, and consequently very expensive. Such a machine appears to me to be very much like the "Great Eastern," built before her time.

It may some day happen that the construction of paper machines will be so improved and the "stuff" worked in such a way as to enable paper makers to work with advantage at this high speed; but I think I am right in saying that the general consensus of opinion is strongly against such high pressure for profitable work. Some of our most enterprising paper-makers have put down high speed paper machines, apparently with no other object than that of outdoing their American rivals, and, although their machines have been constructed by American engineers, as far as I am able to learn, they have not succeeded in approaching the high speeds for which the machines were built. The defect appears to be not in the construction of the machines themselves, but rather to be due to the fact that the general conditions are so different in England, and far less favourable to high speeds than in the United States of America.

In conclusion, I would draw your attention to the great change that has taken place in the paper trade of this country during recent years.

As I have already pointed out, the introduction of substitutes for rags made a complete revolution in the manufacture of paper. Chemistry entered, or rather should have entered, very largely into the manufacture

when rags were the staple article. When Routledge introduced esparto grass, a knowledge of chemistry became more important, and still more so when wood was treated by sulphite and soda processes. But within last fifteen or twenty years another change taken place. It no longer pays to treat wood in England—the wood must be converted into pulp close to the source of supply, consequently the chemical operations have been diverted to Scandinavia, Canada, and the States.

The English paper-maker now takes ready-prepared pulp, and the process of converting into paper is almost wholly mechanical. The users of rag and esparto, still, of course, continue to do the whole of the chemical operations themselves. As you have seen, a paper-mill with two machines producing 25 tons of paper per week was looked upon with awe in 1851. Within the last few weeks we have witnessed the amalgamation of some of the leading "new" mills in the United States, known as the International Paper Company. This company has a daily output of 1,543 tons of paper, not very far short of 9,000 tons of paper per week.

DISCUSSION.

Professor J. M. THOMSON, F.R.S., being called upon, said he was scarcely qualified to discuss paper, but he had listened to it with very great pleasure, and was very glad to find that the Society was able to obtain papers of this kind, containing such an interesting account of the history of the subject. Very often the manufacturers of the present day were so keen in the competition which was forced upon them that they rather put aside the history of their craft, and Mr. Beadle had set a very good example in treating his subject in this way.

Mr. W. G. TREWBY said he also had been much interested in the paper. He remembered some twenty-five or thirty years ago, when he happened to be in the neighbourhood of Mr. McMurray's paper mills in Scotland, being allowed to go over there, and it was pleasant to witness the rapid production of paper from esparto. He should have been glad to hear something further about the use of this material, because when he inquired how it was treated he was told it was a secret. With regard to the manufacture of paper from straw and wood, it was interesting to know that as early as 1800 a book was published on that very subject by a writer named Kooops, in which attention was drawn to the fact that as rags were getting so scarce it was

essary to pay attention to other materials. Half that book was printed on paper made from straw, the other half on paper made from wood pulp. The time ago it was stated in the *Times* that paper made from wood and straw would not last a generation, but this book, made from those materials, and only one hundred years old, was still in his possession.

The CHAIRMAN said they were all very much indebted to Mr. Beadle for his most interesting paper. He agreed with Professor Thomson that it appeared to them in a historic sense especially, that he would have liked to see portraits of the eminent men mentioned, who certainly deserved to be of their country. He recollected many years ago a friend of his telling him that when visiting a village in the neighbourhood of London, he saw a number of old men moving about doing nothing, and asked someone he met how it was there were so many people apparently out of work, though hale and hearty. The reply was that that was the place where bank-note paper was made, and these unfortunate people had "lost their shake." That did not convey much information to him at first, but it was explained to him that in the making of the paper, there was done much as they had seen it that even now it required a peculiar kind of shake to get the pulp on the frame, and that after a man had been at it for many years he sometimes lost the trick of it, and the result was that the Bank employed them off. Paper began with rags, and was made of esparto. In future it seemed as if it should mostly be made of wood, and what had been said about the destruction of the forests was certainly very serious. The matter should certainly be taken into consideration by their friends in Canada. He concluded by proposing a cordial vote of thanks to Mr. Beadle.

The vote of thanks having been passed unanimously,

MR. BEADLE, in reply, said that when he undertook the subject he hardly knew whether he should have addressed an audience of paper-makers or of those who had very little knowledge of the subject. He therefore thought it best to deal mainly with that portion of the subject which certainly ought to interest both paper-makers and the public, viz., the history of paper-making, rather than to enter very much into technical details. He happened fortunately to possess a copy of the book which Mr. Beadle had referred to, which he picked up at an old book-shop at Torquay for 2s., but he had disfigured it by cutting out portions to examine the paper. He believed the strength of the paper was very much due to the fact that it was heavily impregnated with gelatine, and also to the fact which he mentioned in a lecture at the Agricultural Society that certain preservatives were used at the end of the last century which had since been

lost sight of. They could not afford now to use gelatine in paper, because it would cost as much as all the rest of the raw material. He should also mention that the paper, though strong, was of a very bad colour; still, it was wonderfully preserved. He should have much liked to exhibit photographs of the pioneers of the industry, who ought to be revered by paper-makers, but he would point out that portraits of most of them would be found in the paper he had referred to. He found he was not quite correct in saying that Germany was the only country which had taken up the question of forestry, for he noticed that morning that the Papermakers' Association of the United States had formed a committee for the purpose of discussing this question. Germany often took the lead in these matters, but no doubt it would soon be followed by others.

Miscellaneous.

SALT INDUSTRY OF ST. CHRISTOPHER.

St. Christopher, though essentially a sugar-producing island, possesses also means for the manufacture of salt. The two articles require, however, weather as different as day and night for their production. During the last three years rain has fallen in copious showers which, while tending to produce an abundant harvest of sugar cane, has completely put a stop to the salt industry. The south-eastern extremity of St. Christopher, in striking contrast with other parts of the island, is extremely dry and barren, and here is situated the plantation known as the "Salt Pond Estate," covering an area of about 2,400 acres. The United States commercial agent at St. Christopher says that formerly sugar cane was cultivated to a considerable extent, as the abandoned works mutely testify, but this industry has long since ceased to exist. Salt is now the only article that makes the property of value, and it is obtained from a pond at least 300 acres in extent. In form it is oval, and the water around the shores averages from 3 to 5 inches in depth, while in the centre it is about 2 feet. The bottom is covered by soft, black mud upon which the crystallisation takes place. At a distance of 300 yards there is a smaller pond which is used as a reservoir for the preparation of brine, and the western shore of which is contiguous to the sea. The process is as follows. From the sea to the reservoir there is a canal, with a flood-gate through which sea water is let in until a sufficient quantity is obtained. The flood-gate is then closed, and evaporation by solar heat takes place. From a density of about 3°, the ordinary saline strength of sea water, the evaporation continues until 16° or 18° is reached, which is tested by means of a hydrometer. The brine thus formed is transferred through another canal from the reservoir to the salt pond, where the evaporation continues until the

density is 25° . At this point the salt can no longer be held in solution, and its deposit on the mud below commences. Should the surface of the water be unruffled by the wind, the process can be seen to perfection. The salt, looking like grease floating on the water, gradually breaks away and trickles to the bottom, where it looks like thin watery milk. The deposit goes on from day to day until crystals are perceptible, and these increase in size until considered mature, the sides of the top squares of the grains averaging from three-quarters of an inch to two inches in length. The harvesting now begins. The labourers, provided with wicker baskets made in the shape of a basin and holding half a bushel, enter the pond, break the layer or crust of salt (varying from three-quarters of an inch to two inches in thickness) and by means of their hands lift large flakes which are thrown into the baskets. When full, the baskets are moved in the water in such a manner as to leave the salt thoroughly cleansed from mud or any particle of dirt and to cause the flakes to break into grains. This accomplished, the salt is thrown into large flat bottom punts each holding about 30 barrels. When the punts are loaded they are forced by means of poles through the shallow water and soft mud until they are as near the delivery point as they can be got. The salt is then taken in trays and tubs on the labourers' heads to the pile, where it is measured in barrels, the piles containing from 30,000 to 50,000 barrels. The salt is of superior quality and is very heavy, averaging 87 pounds to the bushel. It is well adapted in its natural state, *i.e.*, while the grains are coarse, to the packing of beef and pork, and when crushed or ground to the preservation of codfish, &c. The pond is said to be capable of producing, in favourable weather, about 300,000 bushels.

TRADE CONDITIONS IN NORTHERN CHINA.

Tientsin is the principal port open to foreign trade for North China and Mongolia, and is at the junction of the Peiho River and Grand Canal, 80 miles from Peking, and 57 miles from the sea by river. The Chinese population is estimated at 1,000,000, and the European community comprises about 500. The Netherlands Consul at Tientsin, in a report to the *Consulaire Verslagen*, Amsterdam, says that there are 16 or 17 foreigners employed by the Government in the military, medical, and naval colleges in Tientsin; over 30 in the employ of the Imperial Chinese railways, and others are engaged as military instructors, which is one of the results of the progressive spirit which characterised the government of the province during the tenure of office of Li Hung Chang. The trade of Tientsin is developing, and needs only improved means of communication to become still more important. There is concentrated in that city the commerce of the provinces of Chihli, Shansi, Honan, Shensi, and Nansuh, and also a part

of the trade of the province of Shantung; further there is the trade of Mongolia, and some of the Manchurian trade. The coal mine at Tongshan, about 80 miles north-east of Tientsin, has an average daily output of 1,500 tons, and recently the high figure of 2,000 tons has been reached. The coal is used on the railway and steamers, and coke is sent as far as Hankow, the Yangtze-Kiang, and is used at the Hanyang Iron Works. The coke is made according to old methods and it is intended to build ovens similar to those used in Europe. Tientsin is also the centre of the main roads in northern China; caravan routes to Manchuria, to Mongolia, to the Yellow River, to Chefoo to Hankow, &c., converging here. The roads are in bad condition and during the rainy season are in many places just like rivers. The means of transport are camels, mules, and carts. The Russian transit trade *via* Tientsin and Mongolia, which has increased enormously of late, will be diverted to Vladivostok on the completion of the Siberian railway, but the Consuls say:—"If the Chinese railway schemes at present under consideration are carried out, and if the coal and iron mines in the provinces west of Tientsin are allowed to be worked with foreign capital, the trade of this port may be to a great extent compensated for what it will lose through the diversion of the Russian commerce." Tientsin is connected by rail with Shanhaikwan, 174 miles distant. Other lines are almost completed. The Chinese Imperial telegraph service intends to extend its lines by the construction of a line from Peking through Mongolia to Kiachang, connecting at the latter place with the Russian telegraph system in Siberia.

Correspondence.

COMMERCIAL MUSEUMS.

When spending a few days in a small German town last year, I asked the landlord of the hotel where were the chief manufactures of the district. He told me that clocks and musical instruments were manufactured in the town, and that I should find a representative collection in the Commercial Museum. I lost no time in visiting the museum, and it seemed to me that a similar institution would be very useful in many of our provincial towns and also in London. Admission was free to any person engaged in commerce, and the building contained a well-arranged collection of the manufactures of the district with the manufacturers' names and prices.

At that time I wished to obtain prices and particulars of clocks and musical boxes for the South American market, and in less than half an hour I had seen many suitable articles, and obtained the names of the manufacturers. The same day I called upon the manufacturers and obtained further particulars as to discounts, cost of packing, freights, &c.

The object of the museum was to enable buyers

at once what goods were made in that neighbourhood, and if some 20 or 30 German manufacturers and it worth while to establish such a museum in a small provincial town, surely it would be well if some of our English manufacturers would do the same thing in London or in some of our large manufacturing towns.

I know nothing about the management of this Commercial Museum; it may be a municipal institution, or perhaps under the control of the State; but if such an institution were established in England, the control would be vested in a committee of the subscribers, as a matter of course.

One of the objects of the Society of Arts is the promotion of commerce, and for this it has done much in the past, and may do more in the future, and for this reason I venture to advocate this scheme in our columns. If this idea seems to you worth discussion, I should be very glad to explain at greater length what seems to me the advantages and difficulties, and the best way in which they might be overcome.

CHARLES HOLMES.

24, Aberdare-gardens, West Hampstead,
March 14, 1898.

Obituary.

SIR RICHARD QUAIN, Bart., M.D., F.R.S.—This distinguished physician, who died on Sunday morning, 13th inst., was a member of the Society of Arts of forty years' standing, having been elected in 1858. Sir Richard Quain was born at Mallow, near Cork, on October 30, 1816, and commenced his medical studies in January, 1837, at University College, London, where his cousins—Jones Quain and Richard Quain—were already in office, the former as teacher of anatomy, and the latter as a surgeon. In 1842 he took his degree of doctor of medicine, and was the only candidate of his year who received honours in medicine, obtaining the gold medal and a certificate of special proficiency. In 1851 he was elected a Fellow of the Royal College of Physicians. In 1863 he was appointed one of the six Crown members of the General Medical Council, and since then he was six times reappointed, and was intimately associated with its government as trustee, treasurer, and in 1891 president. He published several courses of lectures, and was editor of the "Dictionary of Medicine."

General Notes.

THE WORLD'S WINE PRODUCTION.—The *Moniteur Vinicole* has recently issued a statement showing the wine production of the various countries

of the world in 1897. The following figures show the yield in each country for that year, and the corresponding figures for 1896:—

	Gals. 1897.	Gals. 1896.
France	711,722,000	982,432,000
Algeria	96,090,000	89,100,000
Tunis	1,980,000	2,094,000
Italy	571,087,000	474,606,000
Spain	415,800,000	392,262,000
Portugal	55,000,000	72,160,000
Azores, Canary, and Madeira ..	5,500,000	7,040,000
Austria	39,600,000	55,000,000
Hungary	26,400,000	25,390,000
Germany	46,200,000	68,420,000
Russia	55,000,000	63,800,000
Switzerland ...	27,500,000	33,000,000
Turkey & Cyprus	39,600,000	67,100,000
Greece	26,400,000	47,300,000
Bulgaria	23,980,000	29,920,000
Servia	20,240,000	24,200,000
Roumania	70,400,000	165,000,000
United States ..	25,234,000	14,960,000
Mexico	1,320,000	1,546,000
Argentine Re- public	31,680,000	34,980,000
Chili	61,600,000	37,460,000
Brazil	8,580,000	10,450,000
Cape of Good Hope	4,290,000	1,980,000
Persia	550,000	704,000
Australia	2,002,000	3,960,000

THE SUGAR INDUSTRY OF GERMANY, FRANCE, AND AUSTRIA.—During the course of the discussion which recently took place in the French Senate on the subject of the sugar duties in that country, some interesting figures were quoted showing the progress of the sugar industry in the three sugar-producing countries—Germany, France, and Austria. During the year 1874-75 France produced 450,000 tons of sugar, Germany 250,000, and Austria 106,000, while twenty years later France fell to the third rank, and Germany produced 1,831,000 tons, Austria 1,046,000, and France 745,000 tons. In 1873 France exported 200,000 tons of sugar, Austria 64,000, and Germany 21,000; while in 1895 Germany exported 1,000,000 tons, Austria 500,000, and France 188,000 tons. The departments in which the largest quantities of beets are produced in France are the following:—Nord, Aisne, Somme, Oise, Pas de Calais, Seine et Marne, Seine et Oise, Sèvres (Deux), Eure, Ardennes, Charente Inférieure, and Loiret. The consumption in France in 1895 amounted to 433,000 tons, and in Germany to 552,000 tons. The total bounty granted in France on the manufacture of sugar amounted in 1884-85 to £1,012,000, and in 1896 to £2,302,000. The quantity of sugar consumed per head of the population in Germany, France, and Austria amounted respectively to 26·7, 27·8, and 16·5 pounds.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock:—

MARCH 23.—“The Preparation of Meat Extracts.”

By C. R. VALENTINE.

MARCH 30.—“Telegraphy Across Space.” By Professor SILVANUS P. THOMPSON, F.R.S. J. W. SWAN, F.R.S., will preside.

Dates to be hereafter announced:—

“Stage Mechanism.” By EDWIN O. SACHS.

“Water Gas and its Applications.” By Professor VIVIAN LEWES.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock:—

MARCH 31.—“The Earthquake in Assam.” By HENRY LUTTMAN-JOHNSON, I.C.S. The Right Hon. Sir HENRY FOWLER, G.C.S.I., M.P., will preside.

APRIL 21.—“Recent Railway Policy in India.” By HORACE BELL, M.Inst. C.E.

APRIL 28.—“India and Currency.” By Sir EDWARD SASSOON, Bart.

MAY 19.—“Chartered Companies and Colonisation.” By Sir ALFRED COMYNS LYALL, G.C.I.E., K.C.B., D.C.L. (Member of the Council of India). HENRY M. STANLEY, M.P., will preside.

The meeting of March 31 will be held at the Imperial Institute; those of April 21, April 28, and May 19 at the Society of Arts.

FOREIGN AND COLONIAL SECTION.

APRIL 5, AT 8 P.M.—“The British Empire, its Resources, and its Future.” By JOHN LOWLES, M.P.

APPLIED ART SECTION.

Tuesday Evenings, at Eight o'clock:—

MARCH 29.—“English Art in Illuminated MSS.”

By Sir EDWARD MAUNDE THOMPSON, K.C.B. Sir JOHN EVANS, K.C.B., D.C.L., Treas. R.S., will preside.

CANTOR LECTURES.

Monday Evenings, at Eight o'clock:—

PROF. W. NOEL HARTLEY, F.R.S., “The Thermo-Chemistry of the Bessemer Process.” Three Lectures.

LECTURE II.—MARCH 21.

The course of chemical change in the “blow”—Thermo-chemical data—Thermo-chemical data in their application to metallurgical operations—Assumed composition of pig-iron—Calculations applied to the “acid” and the “basic” processes—Other calculations—Temperature of the metal—The study of the Bessemer flame and its spectrum.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MARCH 21.—SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. W. N. Hartley, “The Thermo-Chemistry of the Bessemer Process.”

Sanitary Institute, 74A, Margaret-street, W., 8 p.m. Mr. J. Osborne Smith, “Principles of Calculating Areas, Cubic Space, &c.”

Imperial Institute, South Kensington, 8½ p.m. Mr. F. W. Verney, “Siam: Past and Future.”

Surveyors, Savoy-street, Strand, W.C., 8 p.m. Mr. H. M. Grellier, “Tithe Rent Charge Recovery.”

British Architects, 9, Conduit-street, W., 8 p.m. Mr. J. D. Crace, “Heraldic Drawing and its Adaptation.”

Victoria Institute, 8, Adelphi-terrace, W.C., 8 p.m. Mr. Theo. G. Pinches, “A new Babylonian Story of the Flood.”

TUESDAY, MARCH 22.—Royal Institution, Albemarle-street, W., 3 p.m. Prof. E. Ray Lankester, “The Simplest Living Things.” (Lecture X.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on paper by Mr. Henry Fowler, “Calcium Carbide and Acetylene.” 2. Mr. E. W. Stoney, “Extraordinary Floods in Southern India: their Causes, and Destructive Effects on Railway Works.”

Photographic, 12, Hanover-square, W., 8 p.m. Mr. Robert Demachy, “The Gum Bichromate Process.”

WEDNESDAY, MARCH 23.—SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. C. R. Valentine, “The Preparation of Meat Extracts.”

Geological, Burlington-house, W., 8 p.m.

Japan Society, 20, Hanover-square, W., 8½ p.m. Mr. S. Bing Hokusais, “Thirty-six Views of Fujiyama.”

THURSDAY, MARCH 24.—Royal, Burlington-house, W., 4½ p.m. Antiquaries, Burlington-house, W., 8½ p.m.

Sanitary Institute, 74A, Margaret-street, W., 8 p.m. Prof. W. H. Corfield, “Water Supply, Drinking Water, and Pollution of Water.”

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Mr. E. F. Jacques, “The Development of Melody and Harmony in the Music of the Middle Ages.”

Royal Institution, Albemarle-street, W., 3 p.m. Prof. J. A. Fleming, “Recent Researches in Magnetism and Diamagnetism.” (Lecture IV.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Mr. R. Hammond, “Cost of Generation and Distribution of Electrical Energy.”

FRIDAY, MARCH 25.—Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. The Very Rev. the Dean of Canterbury, “Canterbury Cathedral.”

Civil Engineers, 25, Great George-street, S.W., 8 p.m. (Students' Meeting.) Mr. H. O. Eurich, “Internal Governor Friction.”

Clinical, 20, Hanover-square, W., 8½ p.m.

Physical, Chemical Society's Rooms, Burlington-house, W., 5 p.m. 1. Mr. A. A. Campbell Swinton, “The Circulation of the Residual Gaseous Matter in a Crookes Tube.” 2. Mr. A. Stansfield, “Some Improvements in the Roberts-Austen Recording Pyrometer, and Notes on Thermoelectric Pyrometers.”

SATURDAY, MARCH 26.—Botanic, Inner Circle, Regent's-park, N.W., 3½ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Mr. Lionel Cust, “Portraits as Historical Documents.” (Lecture I.)

Journal of the Society of Arts.

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FRIDAY, MARCH 25, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.**CANTOR LECTURES.**

Professor W. NOEL HARTLEY, F.R.S., delivered the second lecture of his course on "The Thermo-Chemistry of the Bessemer Process" on Monday evening, 21st inst.

The lectures will be printed in the *Journal* during the summer recess.

Proceedings of the Society.**APPLIED ART SECTION.**

Tuesday, March 8, 1898; WALTER CRANE in the chair.

The paper read was—

THE MAKING OF A STAINED GLASS WINDOW.

BY LEWIS FOREMAN DAY.

INTRODUCTION.

The making of a stained glass window: how it can be made; and how it should, I think, be made—that is the subject on which I am going to speak to-night.

With the history of glass, with style, we have nothing for the moment to do, and even with design we are concerned only in so far as it bears relation to ways and means, and is determined by them.

A stained glass window is in the first place glazing; a mosaic, that is to say, of pieces of glass—quite strictly a mosaic; as much a mosaic as, for example, a Roman pavement, only it is not marble or any opaque substance that is used, but translucent glass, and the pieces of shaped glass are held together, not by cement, but by an open framework of lead—strips of lead, that is to say (in section something like a capital H) and connected together

at the joints by soldering, are the means we have finally adopted for framing our translucent glass, just as the old enamellers used "cloisons" of metal to form cells for their vitreous colours. Indeed, it is to cloisonné enamel that stained glass in its simplest and most direct form is most nearly related, and not to painting at all.

A mosaic of stained glass can be made (and often has been made) in which the setting is not lead, but stone or plaster. This, however, is an Oriental practice, which has not been much used with us, though there is no reason why it should not, except that our aim is nowadays mostly more or less pictorial, and the Oriental method lends itself more kindly to ornamental pattern.

I have seen a window in which the framework of the glass was of bronze, if I remember rightly. I have myself used a fretwork of brass, zinc, or wood, but the accepted way of glazing is with lead, and on the whole lead is probably the most convenient thing to use. I show you on the screen a couple of Arab windows, the one probably of stone, the other certainly of plaster; and in the next slide a portion of the last mentioned is in colour.

A window of this kind may be regarded as a kind of magnified version of the jewel setting of the East (imagine the setting to be open), in which stones more or less precious are used, less for their intrinsic value, than for their liquid and luscious colour.

The use of small pieces of glass was in the first instance obligatory. Glass was made only in small pieces, and it was precious, far too precious to let even the smallest bit of it be lost.

The scientific century in which we live has achieved monster panes of plate, and we are independent, therefore, of the glazier in so far as clear white glass is concerned.

But for coloured windows, unless they were each all of one colour, the ancient practice still holds good. We have a fuller palette than the mediæval workman (whatever that may be worth), but for each individual colour in a window (with exceptions presently to be made) we have to use a separate piece of glass; and it is the mosaic of these pieces which makes the stained glass window.

For the colour of stained glass, observe, is in the glass itself. That is to say, in the melting pot, with the ingredients of the glass, there is mixed a mineral oxide, copper, cobalt, manganese, which, when the whole mass is molten, stains it red, blue, purple, and so on; for which

reason this through-coloured glass goes by the name of "pot-metal." The term is one to remember: pot-metal, *i.e.*, glass coloured in the melting pot.

MOSAIC.

A stained glass window, then, is in the first place, a mosaic of pot-metal glass, in which the outlines of the design correspond with the lines of lead with which the glass is bound together.

In a mere pattern design of very pale tints of glass (technically "whites") these lead lines are first to strike the eye; in fact, they are the pattern. But if the design is in fairly strong colours, or in white and colour, then it is the surfaces of glass which calls your attention, and the framing lines of lead are more or less lost in the colour, as may be seen (as far as it can be shown in black and white) in the little strips of pattern on either side of the screen.

Experience proves that in the case of, for example, a white pattern on a deep coloured ground, the leads outlining it are merged in the ground, and any lead joints crossing the ground—not part of the design, that is, but introduced for the sake of strength or for other constructive reasons—pass without notice. They do no harm, that is to say. On the contrary, they may be turned to very good account, and the artist takes advantage of them to get variety of colour, which is always so much to the good.

To the good also is the emphatic outline which the lead naturally gives, for the light, as it shines through the glass, diffuses itself, spreads and softens everything, so that the harsh line is not harsh in effect.

A mere mosaic of coloured glass does not go very far, you may say! I have a very strong feeling that it might be made to go much farther than it has ever been carried, that for clerestory and other distant windows it offers splendid opportunity for big, manly, decorative work, in which the material (glass) and its jewel-like brilliancy would be seen at their very best.

But this kind of mosaic (pure mosaic I am speaking of) has never been worked for "what it is worth," because what the patrons of glass, mediæval and modern, have always desired was not so much decoration as picture, and in particular they wanted the window to preach. And so ornament (which Western people don't in their hearts care about) gave way to saints, and scenes from their lives, and

so on. In that direction mosaic, except upon a very big scale, cannot go far. For instance, you can cut a piece of glass to the shape of a face in profile, but for the eye, the ear, the drawing of the mouth, the glazier cannot give you that.

Here comes in the painter!

Just as the glazier, wherever he introduces a leaden outline, stops out the light defining the shape enclosed by it, so the painter may, with solid pigment, stop out finer lines and give detail which the glazier could not. That is to say, the painter can go round the necessarily rather blunt outline of the glazier and accentuate it. He can with his sable pencil make little incursions into the area of the glass where the thick lead would not have room to turn. A leaf, say, is represented by a piece of glass cut heart-shape; the glazier emphasises that with his lead; but the painter can give you the serrations round its edge, and he can pencil in the veining. This line-work is technically known as "pencilling" or "tracing." So far, observe, the painter only does, in a freer and more delicate way, what the glazier does in his rough and ready fashion; that is to say, he only stops out the light. He employs paint not as colour (that is in the glass) but as obscuration. Glass painters' paint, you must know, is an opaque brown vitreous compound fixed to the glass by fusion in the kiln—permanently if the colour is hard enough and the fire sufficient.

On light coloured glass—white, or what goes for it—the traced line is advantageously employed not only for outlining the pattern, but as a means of getting a tint to throw it up. In windows like that you do not notice the cross-hatching of thin lines; you get at a distance the effect of a tint.

That would be so on paper, but it is much more so in glass, owing to the spreading of the light; and the wash of colour, which might be more transparent upon paper, would on the glass produce only a muddy effect.

The process of scraping lights out of the solid paint is an obvious device, which was employed from the beginning. If you want rather fine lines of light or dark, it is plainly much easier to pick them out with one stroke of the stick than to paint round both sides of them. Picking out came in very handily for pattern work; even crude-tinted glass will pass muster when it has been coated with paint and a diaper scratched out of it. What was crude in the mass is only bright in the form of flagree.

PAINTING.

The glass painter's pigment, I said, shuts out the light. If, however, his brush is not fully charged, or if there is proportionately not enough colouring matter in the pigment, the light is not shut out entirely. A thin film of the paint, that is to say, only partially obscures the glass. And so begins what may properly be called "painting," in which the colour of the glass is modified by paint. We are on the way now to shading and modelling.

Glass, however, is rather a slippery surface to paint on. It is non-absorbent: there is no hold for the paint: painting upon it is as different from painting on paper or canvas, as walking on ice is different from walking on dry land. And the glass is as treacherous as ice. Attempt to retouch what you have done, and it gives way beneath you. If you look at any very early mediæval shading you will find it takes the form of a smear (about as flat as they could get it) answering its rude purpose, but that is all that can be said for it. A step in advance is to paint the shadows as best you can, and then dab or stipple the paint until you have got something like texture to it. Obviously you can dab it unequally, removing more paint in some parts than others, and so get gradation of tint. And this stippled surface has an advantage in that it lets light through, and, where the paint is thinnest, you get specks of nearly pure light in the shadows, and so do not lose all translucency in them.

A further step in painting is, having traced your outlines and fixed them in the fire, to coat the entire surface of the glass with a film of paint, and dab it with a stippling brush till it presents an equal granular surface all over. When this "matt," as it is called, is dry (but before it is fired) you rub off with your finger tip the pigment from the parts that are to be light, and then, with a dry hog-hair brush, dust away part of the remaining paint, until by degrees you get the intermediate tints you want between the clear glass and the solid matt. By this means you can get great delicacy of modelling, though you may have to repeat the process of painting (if so it should be called) and repeat it more than once to get what you require, more especially as a fierce fire may wipe out all you have done. You get sharpness of detail by brush touches of stronger colour, and by scraping out lights with the stick end of the brush or other pointed implement; carrying further the practice already explained *apropos* of diapers. Obviously you

may just as well scrape lights out of tint as out of solid black.

In what is called painting, the point becomes eventually perhaps the most important implement of the glass painter. He gets by that his most minute detail, his subtlest modelling, and texture (as, for example, in hair, fur, feathers) to be got no other way. It turns out, then, that "glass painting" in its most accomplished form is not the putting on of paint, but the removing it. It is more nearly allied to mezzotint and etching than to painting. Just as the mezzotinter first rocks his copper and then scrapes down his lighter tints, so the glass painter lays his matt upon the glass and dusts it off to get translucency. Just as the etcher coats his plate with varnish, and with a needle cuts through it to the copper, so the glass painter lays a coat of pigment on the glass and etches through it to the light.

Of course, all or any of the processes described may be used in a single glass painting. For strong, bold work the elementary processes still suffice: for modelling the brushing-out process is most useful: for delicate finish the point has to be used. Delicate work, owing to the difficulty of painting over paint not fixed in the kiln, has often to pass several times through the ordeal of the fire (and it is an ordeal), but accomplished glass painters can do wonderful things in the way of floating colour over unburnt colour, using, it may be, more than one medium; but to do that you must know just how your medium will behave throughout, and you must be extremely dexterous. I need not go into that, because the expert will know more about it than I do, and there is no use in the inexperienced trying their hands at the masterly. Glass is sometimes painted on both sides. I should say that the medium commonly used is either water, with gum or sugar enough to hold the colour, or oil of turpentine—fat oil, as it is called.

GLASS.

With regard now to the glass itself. Folk still go on mumbling the old legend about "lost secrets" in the art of glass making. That is all nonsense. True, the making of glass such as that to which we owe the glory of old windows had fallen into abeyance. The right kind of glass was no longer being made, and when Winston (with the aid of Messrs. Powell and Sons) wanted to revive it the traditions had died out, and they had to solve the problem for themselves. But modern science was equal to the occasion. There is now no

mystery whatever about the composition of old glass; and we can make to-day glass quite equal to any that was ever made, and do besides what the mediæval men could not do. The artistic merit of old glass was in its chemically imperfect composition. It was not only irregular in thickness and in colour, but striated and flecked with air-bubbles; the light coming through it was consequently broken up and deflected, as if by an infinite number of tiny prisms, and so we get the lustrous richness of tone which distinguishes the gorgeous colour of fine glass from the crudity of mechanically and chemically perfect material. This fact once appreciated, there was no great difficulty (to the expert) in making the chemically and mechanically imperfect glass which goes to make perfect windows. What the old makers got by accident the modern get of set purpose—that is all.

There is, however, one advantage which the old material has over the new. We are accustomed to think of glass as practically imperishable. It all depends upon the glass. If there is an excess of alkali in it, glass is literally soluble; it takes a long time to dissolve, of course, but eventually it will dissolve in water. The old glass was anything but homogeneous in its composition; certain particles were more alkaline than the rest, and these more soluble particles have really been washed out of it by the mists and rains of ages, leaving it, on the weather side, all rough and fritted, like an oyster shell. Hence, more prisms, more refraction, mellower and more beautiful colour. The moral is: let us not make our material so scientifically perfect as to resist the kindly ripening of age.

I told you glass painting had to be burnt in. In firing the glass you may change its colour. This is an accident which happens especially to ruby. In the specimens I showed you (part white and part ruby) there is probably in the glass more copper than has actually been converted into colour in the pot. In the kiln this would most likely be brought out, and the white parts would come out ruby, and the ruby parts become so dense as practically to shut out the light. Some colours, therefore, you dare not paint upon for fear of the fire. This difficulty is got over by painting on a piece of white, and glazing this and the coloured glass together (two thicknesses of glass instead of one). The effect is the same as if the paint were on the coloured glass. Perhaps this

process of "plating," as it is called, is sometimes necessary in the pictorial interest, but glass which will not stand the fire is best reserved for portions of the design (background, &c.) which do not need to be painted. "Plating" is used also to get certain tints not forthcoming in any single sheet of glass. That is easy to do, but it is not quite the game. The space between the two pieces of glass is not hermetically sealed; fine dust penetrates, and in time dulls the colour: the surer, but more troublesome, way would be to fuse the two together in the fire.

The annealing of small pieces of coloured glass on to white is also possible, and was practiced in the 16th century. The jewels in the crown of the saint on the screen are represented in that way. The crown is stained, the pearls white, the jewels (ruby, sapphire, amethyst, glass) onlaid and annealed. But, owing to the different consistency of the glass and consequent unequal contraction and expansion with every change of temperature, these onlaid jewels are not very safe, and you generally find one or two of them missing.

FLASHED GLASS AND STAIN.

When I said that in stained glass the colour was in the glass, I said there were exceptions. The first of these is what is called flashed glass. In "ruby" glass, for example, the colouring matter (copper) is so powerful that a sheet of red glass thick enough for strength would be practically non-transparent. This difficulty is got over by making the glass consist of two layers—not a layer of colour upon glass, but a layer of coloured pot-metal upon a layer of white glass. Ruby then is always flashed, a certain kind of greyish blue is flashed, and any colour may be; you may have a layer of one colour over a layer of another colour (not white)—perhaps there are tints yet to be got that way which might be serviceable—but it is chiefly in the case of strongish colour upon white or whitish glass that flashing is practically worth while, for flashed glass admits of a treatment peculiar to it. You can, by means of acid, etch away the coloured layer of glass, exposing the white beneath. (Formerly the red layer had to be laboriously abraded, ground away, but acid simplifies the work and makes it easy.) By this means you can get, let us say, a white pattern on a red drapery. Quite elaborate designs were ground out in the 15th and 16th centuries, and there are practically no limits to what we can do by acid.

STAIN.

There should be mentioned a second exception to the rule of glass being coloured throughout, and even of being coloured in the pot. There is one colour with which glass may be stained (not painted) after it is made. If you paint a piece of white glass with a composition containing a certain amount of oxide of silver, the silver will, under the action of the fire, stain the white glass yellow—deeper or lighter according to the strength of the solution and the heat of the fire. The yellow varies from palest lemon to deepest orange, but always pure and transparent, unless it has been overburnt, in which case an opaque brownish deposit is formed upon the glass. (Glass painters say this is “sulphured;” really I believe the silver oxide becomes metallic silver.) This yellow stain penetrates the glass, and is as permanent as the surface of the material itself. You can get, by using it upon white glass, most beautiful effects of silvery and golden light. You can stain on yellow pot-metal or upon stain; you can even paint with stain, gradating so as to get, for example, very much the effect of embossed gold; you can stain on blue, and get green; on purple, and get olive, and so on.

In the portion of a rosette on the screen (reflected from actual glass) you will see the four rows of petals are of four distinct shades of yellow (defined by the “traced” outline), the white glass showing itself in the eye of flower. In the diaper (also from the glass) the yellow ground is gradated (those cross lines have no business to be there) and perhaps the most beautiful effects of stain are where it is floated on irregularly; the result is sometimes deliciously juicy.

A more pictorial use of stain is shown on the screen in the two kings, from the “Adoration of the Magi.” That is a piece of actual glass—old Swiss—and you see in it a deeper specimen of stain than yet shown.

In the figure from the Last Supper on the screen, the lower drapery is very elaborately enriched with pattern in yellow; and the vase to the right (which is of warm grey blue) is patterned with greenish yellow. (That is at South Kensington, and, by the way, I have to thank the Department for the loan of some of the most interesting slides I have to show you to-night.)

ABRADING AND STAIN.

The limit of what can be done in the way of variety of colour without use of glazing is

arrived at by a combination of the two processes of eating away colour and staining. You can get by so doing on a single piece of glass white and three colours—viz., (1) the colour with which the white is flashed, (2) yellow stain, and (3) the colour resulting from the combination of these two.

I have had a slide made to illustrate this. That is a piece of grey-blue glass; the white is acidied out, the yellow is stained upon white (produced by acidifying), the green is the silver-stain upon the blue. You have there, in a single piece of glass, green herbage, yellow flowers, white flowers with yellow eye, and blue flowers; these last are all that is left of the original tint of the glass. The outlines are traced in brown; the deeper green has a film of the brown over it; a certain russet shade in the leaves is the result of the over-firing spoken of.

A little piece of early 16th century Nuremberg work at South Kensington, of which you have a photograph on the screen, illustrates the more pictorial use both of abrading (acidifying we should use now) and staining. The flagbearer and his flag are in red and white—the white all got by grinding away the ruby—his glove and swordhilt, &c., are stained yellow. All about him is pale grey-blue glass, but it only tells as such in the sky and in the stream below; the landscape is stained to a rich autumn green; the distant castle and the watermill by the side of the stream are white; the blue, of course, abraded. For small work (such as this) flashed glass and stain open out great possibilities. In larger work flashed glass may be used with advantage in diapering, and so on. But the abuse of it leads to a petty kind of treatment not conducive to dignified decoration.

GLAZING.

With regard to glazing. That has to be taken into serious account in the design of a window.

There are difficulties, in the first place, in cutting glass of the thickness and inequality which gives the best colour, and possible as it is to cut certain shapes, it is not worth while, for they are sure to get cracked. The face of a window does not long retain its flat and even surface. It bulges under pressure of the wind, bellies like a sail, and as it yields to that pressure, snap go the pieces of glass which were so difficult to cut. A man who knows his trade not only shapes each piece of glass in his design with a view to convenient cutting,

but anticipates the fractures which would come when the window gave to the wind. (You can tell from the way even the background to the design is broken up with leads, whether the artist knew what he was about.)

With regard to cutting. The glazier, with his diamond, does not, you know, cut through the glass, but only into its surface; it has then to be broken, tapped until it falls apart, following, it is hoped, the lines engraved by the diamond; but your hopes will not be fulfilled unless you take into account the natural lines of fracture.

Another consideration with regard to glazing is the strength of the window. You have, as I said, to allow for wind pressure, and then, when the glass should crack, to guard against it by a joint of lead. A window must yield, it should yield equally, and it is actually stronger when made out of pieces more or less of equal size, and none of them in any case very large.

There are many things it is possible to do in the way of cutting and glazing which it is not ordinarily worth while to do.

For instance, you see the stigmata in the hands of Saint Francis on the screen; they are ruby spots, the hands are white, and the white is not flashed-ruby ground down to the white, but a hole has been drilled in the white glass and a dot of ruby inlaid and held in place by a ring of lead. A glazier would naturally have attached this ring by cross-leads to the lead which marks the outline of the hand.

BARS.

The bulging of the window under stress of wind adds, up to a certain point, to its effectiveness. The various pieces of glass being thus crushed out of the vertical, scarcely two of them are at precisely the same angle to the eye and to the light; and so we get broken light, variety, charm. But, a little too much pressure and the window is blown in!

To keep it safely in its place bars are necessary. These iron bars pierce the stonework, and copper wires, soldered to the leadwork, are tied round them. Bars are usually fixed horizontally across the window, and if it is fairly broad they must not be too far apart—9 inches or a foot is quite far enough—unless there are upright bars also. (You may employ extra stout bars at longer intervals with more slender ones between.) In any case they, too, have to be considered in the design of the window, or they will considerably mar its beauty.

A plan not often used nowadays is to shape

the bars according to the pattern. The schemes of bar arrangements on the screen are from windows of the 13th century, when the practice was common. There the bars form, you may say, the skeleton of the design. The plan is suited to designs in which small subjects, or what not, are set in medallions or other ornamental framework.

A detail from Canterbury, to the left of the screen, shows the relation of the bars to the rest of the design, how the skeleton is clothed with glass. You have—

1. Quatrefoil bars,
2. Extra bar.
3. Horizontal bars at regular intervals.

A complete window from Poitiers shows how the bars may, in a less systematic way, follow and emphasise the design.

1. Quatrefoil not outlined, but the square within it gives lines of bars.
2. Cross-outlined.
3. Bars accommodate themselves.

Whether you shape your bars, or whether you carry them straight across the window, the point is that they have to be considered from the first—not put in afterwards; and I must confess that when an artist does not put them into his cartoon I am inclined to suspect, either that he does not know, or does not care, much about glass. Men, to whom the window is the thing, and not the drawing, often begin by placing their bars, reserving always the right to shift them, if need be, as the design develops itself.

There may be occasions when a bar must be bent out of its course to escape a feature it would not do to cross—but this is a makeshift and a confession of weakness. One would rather see that a man had made up his mind, to begin with, whether to shape his bars to his design, or to design with a view to the use of horizontal bars. Compromise is on the way to nowhere in particular.

GLAZING AND PAINTING.

It is the difficulty of compromising between the conflicting claims of glass and painting, which makes glass painting an art in which it is so easy to go wrong. It is plain sailing enough when the painter accepts the lines of the glazier, and fills in with paint, as in the case of a quarry window. The quarry does not go far, but very beautiful work may be done, in which the main lines of the design are the lead work, and the painting is employed to get further and more delicate detail.

In the Dutch window on the screen the

square quarries of the glazier are accepted, but the design is not confined within quarries. That is in its way a beautiful bit of domestic work; but, notwithstanding the skill of the designer in adapting his scroll, &c., to the rectangular panes, one cannot but feel that the painting is too delicate for the glazing, or the lines of lead too strong for the painting. Still more obvious is the discrepancy between glazing and painting in Da Udine's windows at Florence. It is well, I think, to accept often the simplest lines of glazing, even square quarries, but they should be accepted entirely, and the design should be more frankly based upon them.

In the round-headed window shown the leads follow the painter's design. It is an ingenious design, but the leading is not very ingeniously managed. Most beautiful work has been done by the combination of stained glass and glass painting, but the trouble is that there comes a point where the painter says: "I want more even-tinted glass for my painting; these bubbles, for example, in your glass look like an eruption on the lovely face I want to paint; these streaks of variation in the ruby, &c., interfere with the modelling of my drapery, and so on." And the end of it is that he comes to use flatter, more even, and less lustrous material, relying upon paint to give it quality. And so glass comes to grief. His paint does not, in the first place, give the quality of gorgeous colour which varied pot-metal affords; and, in the second, it does not give quite the quality of painting—that transparency which belongs to actual shadow (as though you could see into it) is not to be got in glass, for there the deeper the shadow the more opaque it must always be.

The unpardonable sin in glass is deep, heavily-painted, shadow. There is no reason why the masses of dark necessary to the most powerful effect should not be glazed up in coloured glass; then they are luminous, and you get all the quality of glass. In heavily-painted glass you don't get the quality of actual shadow which oil or water-colour gives you; it is black, or at best muddy.

Ultra delicacy of painting is another snare. The more delicate your painting, the more sorely you are tempted to avoid the use of leads, which may mar it. But, shirk the leads as you may, you can't get rid of them. You may make them creep round the outline of a cloud, a tree trunk, or a hill side; you may feather the far side of the lead with grass, and so on; but if the outlines generally are delicate, this one will appear, whatever

you do to it, brutal by comparison. And then observe the havoc that time and accident have made with these over-delicate window panes on the screen. There are probably more leads there which are the result of mending than those which were originally in the design.

I am not sure that the objection of the man in the street, or in the church, to leading is not to be accounted for in great measure by his confounding the accidental lines of mending with those designed: and I have known designers deform their work by ugly, awkward, quite unnecessary lead lines, under the delusion that they were thereby giving their work the quality of glass. That is mere ignorance. Still leads must, it seems to me, give the keynote of the drawing, the pitch to which delicacy of painting may be carried. In many beautifully painted windows the lead lines, just because they have been shirked, and only occur where they were inevitable, assert themselves unduly. The face, for example, of the man in the dark cloak on the screen is lost for want of the emphatic outline of lead round the rest of the figure. The fact is, lead necessitates at least some correspondingly strong lines in the painting; here the little patches of black come in usefully in support of the leads, and there is no objection to this use of solid black as local colour in very little bits as here; these are quite small subjects. On a large scale it would be better to glaze up these points of dark in pot-metal. I should say that this glass is of the 16th century, long before Vierge invented the cunning patch of black.

Some of the happiest effects of delicate painting upon glass are where a distant landscape, or what not, is painted upon a pale blue ground which stands for sky. The effect of this is sometimes curiously atmospheric; but the success comes of accepting a convention. The distant view is confessedly painted upon the background tint, and though the hills and trees are stained green, and white clouds abraded, there has been no attempt at naturalistic effect, and no consequent loss of the quality and character of glass.

Delicacy of painting tempts to the use of soft flux (borax, &c.) readily fired and dissolved by action of the weather. It is a fact, not a palatable one to the artist, that soft pigment means perishable pigment. The safest, if not the only, way really to fix paint is to burn it thoroughly in, to use hard colour, painting heavier than you want, and firing it again, and so on.

It is a great question whether delicacy of

painting is a thing worth the sacrifices made to get it in glass. I don't think it is. If you can get it in addition to all else, good; but it is not worth giving up for it qualities which belong to glass. What about the pictorial, then? How far is picture permissible? It all depends upon what you mean by picture. The pictorial idea of the early Italian masters may perhaps be attained in glass. The ideal of the great Dutchman or of the great Spaniard is incompatible with glass painting. And so of course is the ideal of the "plein air" school and the modern pictorial ideas generally. The modern painter wants to get much more than glass will give.

ENAMEL.

The paint so far spoken of has been the brown pigment used for black or shadow, not for colour at all. It is, if you like, an enamel; but it saves confusion to reserve the term "enamel" for colour used for colour's sake upon the glass. Roughly speaking, this may be described as finely-ground coloured glass mixed with something to make it melt easily in the fire, and so become fused more or less perfectly (or imperfectly) on to the glass. Some of these enamel colours will stand more fire than others, but few of them will stand fire enough to make them really one with the glass. Excepting only small Swiss panes (all honour to the Swiss craftsmen), enamelled windows have invariably suffered severely in the course of two or three centuries; so much so that you can always detect enamel by the specks (if not whole patches) of white light coming through where it has caked off. For other than miniature work (in the shields on the screen, for example, which are not much bigger than postage stamps), enamel seems to me scarcely worth serious consideration. For church and other big windows, so far is it from necessary, that it is better to limit yourself to mosaic, which compels you to a breadth which makes for decoration.

CHINA RED FLESH.

The temptation to use enamel-red in flesh painting has not been sufficiently resisted. Flesh colour is just the one pot-metal colour which has not been satisfactorily got. The brownish pink used is not pleasant, and I think it is apt to go purpler in the fire. The best results have been obtained, to my thinking, by frankly accepting the convention of whitish flesh. If there is plenty

of white glass in the window it helps to carry the white through; and there is something monumental about this flesh so removed from nature. However, from the 16th century downwards a warm colour has been used in flesh painting—beautiful work has been done—but the effect is not so fine, I think, as where merely brown is used. After all, you can't get anything like flesh, with its grey tones; you only get a hot monochrome instead of a cool one. Better accept the more manly and more monumental convention.

CONCLUSION.

The root, if not of all design, of all design that can be called decorative (and stained glass is nothing if not that); the root of all decorative design is the material in which it is done, out of which, I may say, it is to grow. An artist can only get out of his material what is in it, and he can only bring out what is in it by, so to speak, humouring it. He shows himself most an artist when he most honours it, using it, that is to say, and not abusing. I don't mean to say that the master craftsman is the slave of his material (it tyrannises, of course, over the ignorant); he has studied it until he knows it, and he can bend it his way. He guides it, as a woman does her husband, without his knowing it; but, like her, he knows how far it is safe to go, and stops discreetly short of the point at which the stubbornness innate in materials (no less than in man) asserts itself at last. And how stubborn things are when you cross their grain! The wise workman works with the grain, flatters the material perhaps, coaxes it certainly into the way he wants it to go; it is to be led (if you know how) but not compelled, and, to lead, you must know. I don't imagine I have taught you much to-night, but if I have made you realise there is something to learn, that was worth doing. Moreover, I hope I may have said something to provoke discussion.

DISCUSSION.

The CHAIRMAN said they had had (as might be expected from the author of a learned and practical work on the subject of stained glass) an extremely able, interesting, and practical paper. Not the least interesting part of it had been the admirable series of illustrations. He did not remember to have seen before so striking a series of illustrations of the actual glass which had been given. The reader of the paper had illustrated the capabilities of

glass in a degree which he should have hardly thought possible to have demonstrated with a lantern. They had had a series of pictures also, taking one over the whole field of design generally. With regard to the tendency toward pictorial treatment, Mr. Day had incidentally condemned it, and they found, by the specimens shown, how an apparent advantage was gained at the expense of the more important artistic quality of realising the conditions of the material. Few things were more thoroughly delightful to his mind than the simple Oriental mosaics of glass set in a screen of stone or plaster. Beautiful and elaborate as some of the 15th and early 16th century examples were, one felt there was a little endeavour to escape from the actual conditions of a craft which all should bear in mind, and that, clever as certain attempts at realism might be in themselves, they were obtained at too great a cost. His mind certainly reverted with pleasure to the somewhat rude methods of the 13th century glass painters, where great stress was laid upon the lead design and the tracing. Directly one attempted to escape from the necessity of making a design in lead lines, one lost a certain character, and, therefore, beauty, belonging to the expression of glass design. Pictorial treatment must be governed by the proviso that pictures must be patterns. The best glass design should satisfy the eye as an arrangement in plain glazing, first of all, independently of the colour, its fine glory and conception.

Mr. HARRY J. POWELL said he was glad of the opportunity to thank Mr. Lewis Day for his most able and interesting paper, the value of which would be appreciated by all who were interested in stained-glass windows. The need of such a paper, and the ignorance which prevailed as to the merits of stained glass, was well illustrated in Mr. Day's book, "Windows," a book which would be the classic of the art of stained glass for many years to come. He there tells us that visitors to the ante-chapel of New College, Oxford, invariably turn their backs upon the beautiful old windows, and gaze with rapt admiration at the unsatisfactory effort of Sir Joshua Reynolds. Last summer, he (Mr. Powell) had to spend a good deal of time in New College Chapel, and could fully corroborate Mr. Day's statement. He must congratulate Mr. Day on his courage, as an artist, in declaring that coloured glass is now made which is in all respects equal to the old. As a glass maker, he could not concur without some reservation. Glass is now made which, so far as the spectroscope can tell us, is identical with the old glass; but, somehow, when it is put into a window, and is put by the side of old glass, it has not always quite the same effect. This may be the fault of the material, or it may be the fault of the artist, who has not fully grasped the technique of "obscurant," to which Mr. Day had referred. The difference was often attributed to "weathering," and

weathering, undoubtedly, had something to do with it, but a good deal even of 13th century glass is not perceptibly weathered. The old glass was laminated and horny, and to give this nature to modern glass (*i.e.*, to make unscientific glass scientifically) is by no means a simple operation, or one that is invariably successful. His chief reason, however, for rising that evening was to thank Mr. Day for his acknowledgment of the work of Charles Winston. If it had not been for Winston, the masterpieces of Burne-Jones and Morris could not have been produced, and English stained glass would not have been, as it was proved to be at the Paris Exhibition of 1889, far in advance of the stained glass of any other nation. Winston was a barrister, and a devoted admirer of stained glass. He discovered that the beauty of old windows was due to the material, and he set to work to find how the modern material differed from the old. He called to his aid another barrister, an amateur chemist, Mr. Harwood-Clarke. By repeated analyses and researches into the works of Theophilus, they first satisfied themselves as to how the old glass was made, and then laid siege to the Whitefriars Glass Works, and insisted on modern glass being made in the same way. They carried their point by "worrying," and if the glass now used for stained-glass windows may be compared to the old glass, the credit should be given to Mr. Winston. As Mr. Day had pointed out, glass and lead were the essential elements of a stained—or, he would rather say, a "mosaic"—window, and a window, to be truly decorative, must be drawn in "lead lines" and painted in gems of coloured glass.

Mr. JOSEPH PENNELL said he did not know that the Moorish windows were composed of stained glass. The windows of the Alhambra in Spain were of open wood work, the result being that when the light shone through them it cast beautiful shadows. Some of these windows were inlaid with little bits of ivory and coloured wood. He should like to know what Mr. Day thought of the work of Tiffany and La Farge.

Mr. WILLIAM J. BOOER, speaking of the staining process, said, to his mind, the great beauty of many of the yellow stains was owing to the fact that the glass made a long time ago was of a much softer material. When he said "soft," he meant with reference to its absorbing the silver, and thus the beautiful rich ruby graduating down to a pale lemon was easily produced. Many years ago, Messrs. Chance, of Birmingham, made a glass of this description, but, owing to the small demand that there was for this kind of glass, they had discontinued making it. This soft Kelp glass really accounted for the richness of the stain. A rich ruby could be obtained by staining it with silver on both sides. With reference to the modern makes of glass, a new line of discovery had been made owing to the suggestions of Mr. E. S.

Prior, an architect, who had almost brought back many of the choice examples of the old glass. There were some specimens on the table, showing the difference in thickness and the gradation of colour. Architects, as a mass, had not interested themselves much in the quality of glass. He remembered a short time ago calling upon an architect at Eastbourne, and showing him some very fine specimens of glass, when the architect said, "I never saw any glass like this before; and I do not think much of it!" The specimens were considered to be very choice indeed. Calling upon the same gentleman a month afterwards, when something on the glass had been printed in one of the art papers, he then said, "I did not see any beauty in the glass until my attention was called to it, but it is really beautiful glass." The ignorance connected with glass was very deplorable. The glass trade, as a rule, had been very neglectful in bringing this ignorance before the public. Immediately people entered a church, if they saw plenty of red, blue, and yellow colour, they said, "What a beautiful window." He thought they were much indebted to Mr. Day for the very terse way in which he had put the whole matter before them, and having been brought up as a glass stainer, he could honestly say that he had appreciated the paper very much.

A vote of thanks to Mr. Day was carried unanimously.

FIFTEENTH ORDINARY MEETING.

Wednesday, March 23, 1898; MICHAEL CARTEIGHE, Member of Council, in the chair.

The following candidate was proposed for election as a member of the Society:—

Starley, John Kemp, Barr's-house, Coventry.

The following candidates were balloted for and duly elected Members of the Society:—

Bell, Horace, 28, Victoria-street, S.W.

Dobree, Harry Hankey, 34, De Vere-gardens, Kensington, W.

The paper read was—

THE PREPARATION OF MEAT EXTRACTS.

BY CHARLES R. VALENTINE.

Almost exactly two years ago I addressed a gathering of your Society here on the subject of the development of the trade of our Colonies in dairy produce and the products of *petite culture*. If I felt some diffidence then, I must confess that I feel more diffidence to-day,

because I fear I shall have to tell you a good deal that you know. I will, however, endeavour to do so without being wearisome, and in the hope that I may at least make suggestions that may be of use. I am going to deal with the production and use of meat extracts—so called—and to endeavour to show that Australasia may still further develop a useful and important and remunerative trade in a material that is now the basis of a host of dietetic preparations, the virtues real and fanciful of which are indicated by the advertisements that cover the walls of our streets and fill the pages of our newspapers and magazines *ad nauseam*.

(1.) I will first give some account of the history of meat extracts, and the causes that have led to their manufacture and use.

(2.) Then I will treat of the commercial aspect of this manufacture, and give some statistics of the Colonies in which I think a very profitable trade may be further developed.

(3.) Then I will refer to preparations that are in fashion at present, and their general manufacture and composition.

Perhaps nothing strikes one more forcibly in visiting the great centres of food distribution in England than the changes that have taken place in the last thirty or forty years. These changes appear to be governed by the general rule—"the luxury of yesterday gradually becomes the necessity of to-day." To go back not a very long time, we can trace this evolution in the use of the universal vegetable the potato, and in the abuse of that often harmful and nauseous decoction stewed tea. These are instances of supply creating demand. The booming and advertising of *bouillons* and extracts of meat has led to something similar in the case of meat extracts, or rather "extracts of beef," all of which have their basis in the product I am about to discuss that is known by its Latin title *extractum carnis*. Before dealing with its history, let me say at once that this raw material, the basis of these popular drinks, *bouillons*, and extracts, can be made in the Colonies at a cost that will enable it to be placed on our market at a price within the reach of everyone. Hitherto the price has been quite prohibitive. Popularised in a still cheaper form, it will meet an increased demand, helped undoubtedly by the tendency of the age in this world of rush and hurry that requires everything to be ready to hand, with the minimum of labour and the maximum of quality. Until recently, even in the best

kitchens, the use of "extractum carnis" was unappreciated, and the advantages of its application in the making of soups, hashes, stews, gravies, &c., overlooked. There is yet room for a great development in the form in which it is placed ready to the cook's hands, *i.e.*, in clean and easy form for use without being wastefully packed. From another point of view, the manufacture of useful and reviving beverages from "extractum carnis" is to be encouraged as an antidote to alcoholic stimulants which flatter the weak heart "but to betray."

The development of our empire, too, is only now rendered possible by these portable and sustaining extracts. Pemmican and biltong were all very well, but now the question of whether an army corps can reach Coomassie with its available transport service, or whether a forced march beyond Berber, on the Nile, is possible, may depend upon such goods as are known by their epithets, "extract," "condensed," "compressed," &c. Lastly, in the sick-room and hospital, the value of a preparation of known strength, purity, and character may mean the saving of life. Scientifically made, there is no fear of a patient being nauseated by the watery infusion that many of us remember we have been compelled to swallow in our sick days of childhood, accompanied with its modicum of dry toast, until the very name of "beef tea" has caused us to shiver. There being this extended use for a good meat extract in the kitchen, in the tented field, in the peaceful scientific exploration far from the base of supplies, in the sick-room, and in daily life, as the basis of a useful, palatable, and honest beverage, the corollary follows that there must be an ever-increasing demand and popularity. To meet this demand, we wish to place Australasia, and especially the cattle-rearing colonies of Queensland and New South Wales, in the forefront.

The idea of concentrating the body of an ox into a thimbleful of elixir must have been a very old one. May be, the love potions and philtres of ancient and medieval witches were merely strong *bouillons*, in which, when beef was scarce, "eye of newt and toe of frog" were used in the cauldron! Perhaps, in those days those came nearer to a true appreciation of the physiology of life sustenance who gave their patients raw meat. It must be remembered that meat extracts and concentrated foods are to meet the special circumstances of the sick, and not to supplant but to assist other foods with both them and

the health. The work of Dr. Justus von Liebig in this respect has hardly met with its due appreciation. Certainly his name appears in various colours on different-shaped jars of different preparations, but the light he threw on the physiological action of food, upon its chemistry, and upon the concentration of its valuable constituents, has been forgotten and unappreciated, and, like Pasteur, the bulk of his life's work is overlooked and his name is only familiar to many of us in connection with a minor result of his devotion to study for the benefit of humanity. Be this as it may, Liebig, who died exactly a quarter of a century ago on April 18, laid down certain great principles of the chemistry of food which hold equally to-day as when he enunciated them.

Years before Liebig, the celebrated physicians, Parmentier and Proust, endeavoured to procure a more extended application of the extract of meat; and Liebig, in his "Familiar Letters on Chemistry," published in 1859, quotes them, and shows how Parmentier had pointed out that extract of meat would offer to the wounded soldier a means of invigoration, and, with a little wine, "instantly restore his powers weakened by loss of blood." Proust speaks in similar terms. Now Liebig, ever with a keen eye to the practical when any new scientific truth was elucidated, pointed out 50 years ago nearly that from the continents of America and Australia, where beef and mutton had then only a nominal value, we could, with the simplest means, collect immense quantities of the best extract of meat, the importation of which, he adds, "might perhaps acquire a very peculiar importance for the potato-eating population of Europe." It is equally important with the right manufacture of a meat extract that the public should know exactly what it is, and its true place in dietetics. In touching upon this chemico-physiological aspect of the matter, it must be understood I only give the broad outlines, and that there are modifications of the principles laid down; but for my purpose, and for the purpose of the manufacture of "extractum carnis," these broad principles obtain to-day equally as they did when Liebig first laid them down.

When raw meat is finely chopped and macerated in the same weight of cold distilled water and squeezed out, the water dissolves from 16 to 24 per cent. of the weight of the dry flesh. The fibrine of the flesh is about three-quarters of the solid residue. If the watery

infusion be heated, the albumen of the flesh separates as a flocculent precipitate when the temperature of 133° Fahr. is reached, and the red colouring matter of the blood, likewise albuminous, coagulates at 158° . The infusion, after being freed by boiling from albumen and the colouring matter of blood, has the aromatic taste and all the properties of soup made by boiling the flesh. This is important to remember in our manufacture of extract. There is no idea harder to eradicate from the mind of the old-fashioned cook or housewife than that the longer she boils meat the more good she is getting out of it. She is a loose observer of facts. She is condensing the extract she has made, but she is only making the fibrinous albuminous part of the meat more recalcitrant than ever. Anyone who has boiled an egg is familiar with the coagulation of albumen, but the cook will not listen to anyone who points out a similarity between eggs and meat. Perhaps, the same spirit that rises superior to a little elementary chemistry inspires the vegetarian and the fasting ascetic with the self-comforting idea that in eating eggs they are loyal to their creed, whilst beef would be "anathema!" We return to the infusion or extract of flesh from which we have strained the coagulated albumen. This infusion when evaporated at a gentle heat becomes darker-coloured, finally yellowish-brown and acquires the flavour of roast meat. When it is dried up, there is obtained a brown, somewhat soft, mass amounting to 12 or 13 per cent. of the original flesh (suppose it had been dried). This is in the rough the outline of the process of extract-making.

We have rather overrun our ground, and must just hark back to a word or two about food. From the air and soil and the rain plants with the sun's aid build up their structures, and these contain, roughly speaking, two great classes of organic compounds, both necessary to the food of animals. These are (1) the carbohydrates, or non-nitrogenous, such as sugar, starch, cellulose, and the fats; (2) the nitrogenous (albuminoids), such as the gluten of flour, which is vegetable albumen, and the vegetable casein that is found in beans and peas. The plant is eaten by the graminivorous animal, and that animal is eaten by man. There are, of course, mineral matters in the plants which have important functions. You all know that nitrogenous food-stuffs are absolutely essential for the well-being of animals, and that without them the animal frame cannot be built up. Liebig

illustrated this by calling attention to the fact that from the albuminoids of an egg develop all the parts of the animal body—feathers, claws, membranes, fibrin, blood-vessels, and so on. In the process the albumen disappears. Albumen then, he points out, is "the foundation of the whole series of peculiar tissues which constitute those organs which are the seat of vital actions. The elements of these organs which now possess form and vitality were originally elements of albumen." Albuminoids, then, must be present in every food which by itself suffices to support life. The meat or muscle of herbivora consists largely of solid albuminoids, and hence its importance as food, and it is this difficulty of albumen coagulation that stands in the way of the manufacture of an extract of meat that would be life sustaining by itself. Methods have been adopted to overcome some of this difficulty by the restoration to the extract of the coagulated albuminoids, but in the ordinary "*extractum carnis*" of commerce the great bulk of the nitrogenous constituents of the meat is absent. If special claims are made for any preparation of it, these claims must be based upon constituents added to it by the manufacturers and patentees of the many preparations, excellent in their way, that are on the market.

The great principle to remember in the manufacture of meat extract is that if flesh employed for food is to become again flesh in the animal body, as few as possible of the constituents of raw flesh ought to be withdrawn from it in its preparation for the table. It is not claimed for "*extractum carnis*" that it is a food. It is plain that if flesh be simply boiled in water and the meat eaten, much of its constituents have been lost, especially if it be put in cold water at first. It is possible, as I have shown above, to extract from finely divided meat by the action of cold distilled water, a great deal of albuminous matter, and therefore cooks are warned not to steep fresh meat for long in cold or warm water. On the other hand, washed muscular fibre becomes hardened by boiling it in water, just as does the white of an egg. It is important, therefore, that the cook, if she wants tender meat, should drop it at first into boiling water, and thus form, outside the meat, a layer of hardened fibre and coagulated albumen, which keeps the other juices in the meat, and the albumen among the fibrinous parts inside. The meat should never be allowed to boil hard, but merely to stand and simmer. The effect on

fibrine of boiling is, we must all remember, to increase its hardness and toughness. The same applies to the roasting of meat; the exterior should be rapidly heated, to form an envelope, as it were, to retain in the meat the interior juices. This is, roughly, the *rationale* of cooking, and it will enable my hearers to recognise that beef-tea is but a solution of the saline and extractive matters of beef, whilst the extract made by the Liebig process is an evaporated beef-tea containing, in a small volume, the extractive matters and the salts of a large quantity of beef, and in virtue of this, possesses medicinal and dietetic properties not to be despised. Considered alone as a food, it in no sense represents the meat which has yielded it, since it has lost the albuminous element. We will just destroy one other fallacy of the kitchen before passing on to our subject. A cook will judge of the "strength" of her stock by the fact that when cold it was a stiff jelly. Now, as far as nutrition is concerned and life-sustaining power, the thinnest, most watery-looking cold fluid may be of infinitely more value. The jelly is gelatine, differing nothing from any glue or the like extracted from the feet of cattle. Liebig, with other chemists, showed that gelatine itself has little or no dietetic value, in spite of the nitrogen it contains. It will not support life alone, nor will it even replace meat; 50 per cent. of it leaves the body without having helped towards its nourishment, and the remaining moiety goes partly to form fat, or passes away in the form of urea. It has, however, some value in a mixed diet. The cook's gelatinous soup is then not so "good," so "sustaining," as the watery amber-coloured fluid made from the maceration of minced raw beef with water. It is to some extent upon the intelligent method of making a true soup that the process of the manufacture of "extractum carnis" depends. Liebig macerated finely-divided beef in cold water, or water heated up to about 150° Fahr. This is evaporated to dryness in a water-bath, and forms the extract of beef. From some 32 lbs. of lean beef, free from fat and bone, equal to 8 lbs. dry meat and 24 lbs. water, 1 lb. of true extract of beef can be made. Liebig further pointed out that of the true extract nearly 80 per cent. is soluble in alcohol of 85 per cent. In salting meat, the brine that forms contains all the elements of the extract, and you can therefore see what a wasteful plan it is to kill and salt down cattle to export salt beef. Salt beef is not a healthy food, it is bulky

to export, and its better qualities have been running away in a useless brine, whilst the composition of the flesh is changed much more even than by boiling. "Extractum carnis," then, is free from fat and gelatine, whilst the beef of our kitchens contains both. If "extractum carnis" contained fat it would not keep, but become rancid; if it contained gelatine it is depreciated in value, for the best dry gelatine is only about half the price of extract of meat.

You will naturally ask what is the value of meat extract, as apparently its qualities, as referred to by me, would seem to be mainly negative, in that I have only said what it does not contain. Liebig saw in it the means of bringing to Europe some part of the food that was wasting at a distance for the want of anyone to eat it. At the time he wrote, lean beef in Australia was worth from ½d. per pound to nothing; but he meant the extract to be eaten with liberal additions of bread, peas, or lentils; that is, with foods that contained nitrogenous constituents, in which the meat extract, by reason of the process of its manufacture, was, of necessity, lacking. To-day in the modern German factory this is being done. The famous *erbwurst* of the German soldier is peameal and meat extract with little bits of fat bacon chopped up in it. And—let me mention it with some shame—the preserved vegetables the English troops took with them in the last Ashantee expedition were preserved in a German factory, where the meat extract is "strengthened," literally, to-day by the addition of vegetables, peameal, &c., and made into appetising and sustaining soups. Thus, to-day, Liebig's idea is being carried out, and now the German soldier is supplied with his meat extract separately, and his peameal and bacon fat and nitrogenous vegetables to put in it. Vegetable albumen, in fact, is supplied separately to the soldier to put in his extract. At the same time, even "extract" with the vegetable albuminoids is not equal to the meat from which the extract is got as a life-sustaining diet.

The exact action of the extract alone is perhaps more that of a useful stimulant, and it is in its development in this direction that there seems to be very great opportunities for its extended use. Its physiological action is not perfectly understood, but seems to be akin to that of the action of the alkaloids of tea and coffee. The lowest and latest mixture—a *louillon* made from "extractum carnis"—is retailed to-day at 6d., and the

purchaser is obliged to take more than he requires for one cup or for a single person. In a ready, suitable, neat, and clean form the sale of extract of beef in small quantities sufficient for three-quarters of a cup of hot water should be a successful rival of the popular "pint of four ale." The extract is, in fact, a substitute for flesh when taken with suitable accompaniments, the best of which, I should imagine, would be whole-meal bread, in which the wheat is not robbed of its vegetable albuminoid gluten, as too much of the fine flour is to-day. Popular as are the preparations of extract on the market, we can yet imagine what a wonderful demand might be created if the minds of the people became accustomed to use them, and had them placed before them in small cheap quantities that could be prepared even more quickly, as a beverage, than the dreadful decoctions of our railway refreshment rooms and restaurants, called tea and coffee.

If the preparations of meat extract on the market are not legion, they are, at least, a battalion; and I may roughly divide them into four great sections:—(1) Extracts by the Liebig process, or modifications of it; (2) *bouillons*; (3) jellies; (4) juices.

Of the first, we have Liebig's Extract Co. "Liebig," blue signature; "Ramornie" Liebig; "Tooth's" Liebig; Baron Liebig, photograph brand; "Brand's" Liebig; Cybels; Armour's Extract (Chicago), modification of the Liebig process, whilst many large wholesale grocers and warehousemen put up the extract under their own names, and these are all on the Liebig system.

The second class, we may call flavoured and medicated solutions, such as Bovril, Vimbos, Borthwick's *bouillon*, Oxine. It is claimed for these that there has been restored to the extract some of the albuminoids that coagulation and straining have robbed it of. These are more of foods, but not so stimulating as the Liebig because not so condensed. In the case of Oxine it is also claimed by the makers that vegetable matter is added.

The third class, the jellies. These are made by boiling down the gelatinous parts of meat, as well as the lean meat, until a jelly is formed, and this in many cases is fortified by the addition of the extract. In this class (jellies) the well-known Brand's essence of beef might be included.

There are also a number of meat juices, under the names of Armour's, Brand's, and Valentine's. The colour of this juice is reddish,

which shows that in the preparation it has not been subjected to great heating. The makers claim special methods of manufacture. In some cases the lean raw meat is taken and minced, and an equal volume of water added; it is then squeezed under great pressure, and strained. The juice is then frozen, the water in it freezing out first, the excess of water being separated by a special process.

These are the only four classes of meat extract, and I may say of the first three of them that extract of meat is the basis of all. The popularising of these essences, *bouillons*, Bovrils, and Vimbos, &c., means that there is an increasing demand for extract. There are some "soup squares" made, but they are manifestly largely gelatinous, with starchy and vegetable matters added, together with a small amount of extract. It is also to be borne in mind that a very dark extract is not necessarily a strong one, as the deep colour may be due to vegetable colouring matter. The keeping properties of extract are valuable, and the absence of the albumen has much to do with this characteristic.

There is a meat fluid made which consists of lean meat chemically treated with acid and peptone, by which all the fibrin, albumen, and gelatine are rendered soluble after being digested in water at a temperature of 100° Fahr. It is treated with other chemicals to remove the bitter taste, and then evaporated, and as such represents certainly all the lean meat. But for manufacture on a large scale, and from a commercial standpoint, the "extractum carnis" is a more profitable undertaking, in that its manufacture is simple, easily conducted in large bulk, and no somewhat risky chemical treatment is needed for its production. On a large scale, too, this condensed solution of beef would I imagine be an expensive product; "extractum carnis" can be made cheaply and well, and has a big market ready for it.

I think it only proper to refer to Brand and Company, who rank amongst the first producers of concentrated meats in this country. This house was founded in 1835 by a Mr. Brand, who had for many years been a cook in the kitchen of King George IV. Mr. Brand commenced business upon a modest scale in Little Stanhope-street, and the goods he made a specialty of at first were chiefly *patés* and edible delicacies of varied kinds, supplied to an aristocratic *clientèle*. The business continued thus until 1845, when the concern was disposed of to a Mr. Withall, who carried it on upon the old lines until 1861.

In that year his friend, Dr. Druitt, urged him to endeavour to perfect and introduce to the medical profession some form of nutriment that patients might take in lieu of medical stimulants, and which should embody the large amount of invigorative power in a small compass. Experiments were undertaken, and the result was the introduction of what is now known as "Brand's Essence of Beef." This preparation has from that time to the present day enjoyed an increasing sale, and Dr. Druitt was its first introducer to the faculty, he bringing it before the Obstetrical Society of London in May, 1861. The "Essence of Beef" and the "Concentrated Beef Tea" formed a nucleus around which other specialities have since been gathered, and from that time onward the house has progressed upon its new basis with remarkable success, playing a most important part in the production of special articles of diet for invalid use. In 1873, Mr. Withall transferred the business to its present proprietors, Messrs. Thomas Deuce and John James Mason, the latter of whom had for many years been the superintendent of the culinary department.

I will deal now with the stock statistics of Queensland and New South Wales. We have no figures relating to the import of extract of meat. It is lumped together with "meat preserved otherwise than by salting," in the Board of Trade returns, and this country pays a bill of £2,000,000 per annum under that head. It is not likely that the trade from the United States will greatly develop, its vast trade in cattle and beef being the line which is more suitable. We paid the United States of America and Canada nearly £10,000,000 for live cattle last year, besides £4,609,000 to the former for fresh beef. The trend in Argentina, too, seems to be towards live cattle and fresh beef export. It is to be noticed, too, that there has recently been a considerable advance in the value of stock in the United States of America, and this concurrently with an increase in number. Let us not forget America's vast resources—in Texas alone there are 1,000,000 more cattle than in the whole of England, and a cow there is only worth from £3 12s. to £4, other cattle being valued at under £3. In Australasia, in 1895, there were, roughly, 12,000,000 cattle, nearly 7,000,000 of these being in Queensland and 2,250,000 in New South Wales. New Zealand carries over 1,000,000 head, and is increasing her herds rapidly, possessing as she does immunity from disease. For the

United States of America, 50,000,000 is a moderate estimate; and Argentina must have getting on to 40,000,000, for she had 23,000,000 six years ago, and the development has been rapid. In 1895, Argentina sent to us 12,213 cwts. of "beef preserved otherwise than by salting," the United States of America sent 253,261 cwt. of the same, and Australasia 171,000 cwt.—a very respectable quota indeed. Roughly speaking, nearly all this came from Queensland and New South Wales, in the proportion of two-thirds of it for the former and one-third for the latter. It may just be noticed in passing that figures recently issued show that in 1897 the exports of live cattle from Argentina were 238,121 head, or 144,418 fewer than in 1896. At the same time the frozen beef export increased from 2,997 tons to 4,241 tons. But as there was a decrease of 9,668 tons of jerked beef, as compared with the exports of 1896 from Argentina, the result is that in 1897 the aggregate exports of beef altogether show a considerable decline. Now stock in that country have been much improved by the large purchases of English bulls, and it is apparent that the trade was checked by cheapness here, whilst probably there has been, by reason of the improvement of stock, an appreciation of value over there. It would appear that Argentina will eventually send the bulk of her beef here as chilled meat of high class. I will place the other beef exports to England of these countries and colonies side by side for the same year:—

	Cattle. 1896. No.	Fresh beef. 1895. cwts.
Argentina	65,708	23,384
United States	393,548	1,649,473
Australasia	32	502,168

Queensland, especially, with her large surplus of cattle, has developed the meat extract trade considerably, and that this is so is largely due to the foresight of Mr. C. G. Tindal and Mr. Tooth, two of the pioneers of the Australian preserved meat industry. The former's name is identified with the celebrated Ramornie brand, and he has latterly devoted much of his attention to the extract trade. From Queensland alone in 1895 there were exported 474,746 lbs., valued at £43,000. There is one advantage about the extract trade, too, that I may notice. Tinned and preserved meats have dropped in value by reason of the great development of the fresh meat trade. Extract does not enter into competition with either. It has its own

market; it is *sui generis*; it is the luxury becoming the necessity.

A great many colonists are looking at the trade with longing eyes, and there is something of a rush into it in the colonies referred to because of the manifest advantages. There is all the more danger of the trade being injured by loose methods of manufacture. The trade can no more afford this than could the dairy trade, and it is of the utmost and absolute importance that Australian "extractum carnis" shall earn and maintain the highest character. The utmost care in manufacture is necessary, for one ounce spoiled by burning affects the whole bulk. There must be the latest machinery for cutting the lean meat, hydraulic pressing, perfect cleanliness, perfect command over the temperature of the buildings and apparatus, cleanly and quick disposal of the offal, fat, &c., and no accumulation of the meat awaiting treatment. The beef must be freshly killed, mature, but young beef fed in good condition so as to carry the maximum of lean flesh. Cattle over three years of age, and not over four years are, in fact, the best for the purpose, and are those from which the maximum quantity can be made. The meat is stewed by steam (I use the word in preference to "boiled") in a jacketed vessel, and the concentration of the clear soup is generally done in vacuum pans. Every detail is of the utmost importance. An essential point is the cooling of the meat after killing, and, as in the dairy, a perfect command of the temperature is needed. Meat chopped and laid aside in bulk very soon begins to "change." A first-rate extract cannot be made except from the best, cleanest, and sweetest meat. None other but the best is wanted in England. The business lends itself to the co-operative method among stockowners supplying the extract factory, and this especially in the disposal of the bye-products. There is all the fat, which has various uses, the meat of the head, neck, &c., the heart, liver, tongue, sweetbreads, blood, entrails, hide, switch, bone, feet, horn, &c., all severally valuable commercially; and on the disposal of these or preparations of them in the rough as marketable commodities, such as glue, tallow, cured skins, charcoal, manure, &c., will depend to a great extent the stock-raiser's profits. It is not a trade that anyone can rush into, and it must be begun on a perfect system. An ordinary fat bullock gives 400 lbs. or so of lean meat, which produces about 10 lbs. of extract. It varies in price, and it only pays to make the best. The importance

of the bye-products will be recognised as a big factor in the commercial success of an undertaking of this nature. In Chicago where, of course, immense numbers of cattle are slaughtered, the bye-products are turned to the best account in a systematic way, and the exporters even of the prime beef depend largely upon these for their profits. The skull of the head with that of the legs and tail goes to the glue factory; the cheeks are used for Bologna sausages; the tongue is pickled and smoked; the skull goes to the glue-house and is boiled, and then to the fertiliser factory the feet make glue and neats-foot oil, and the bones of them go for tillage; the sweetbreads are used to make pancreatin; portions of the liver and heart are used for sausages; the blood goes to the maker of fertilisers, and the horns are made into knife-handles, buttons, and combs. It is through the saving and utilising of absolutely every portion of the bullock that the packer can make his business pay as well as does, and as an example of the completeness and economy with which all bye-products of thousands of stock are utilised, I cannot do better than refer to Mr. P. D. Armour, of Chicago. At Armour's works this utilisation of bye-products is carried on to perfection. There is absolutely no waste. The country butcher in England, who kills two bullocks a week, lets more run to waste than is lost in the disposal of 100 head at Armour's.

The first samples of extract that came from Australia were very good, but as new packers rushed into the trade a deterioration was noticed, due to improper treatment and careless selection of the meat, and to the neglect to expel all the water, or carelessness in heating and consequent burning. The latest appliances of mechanical skill must now be used at once in the dairy, and rule of thumb and guess work must give way to science and exactitude. In the best constructed and managed works in the colony every care is exercised in the selection and treatment of the meat, and where the rough and ready idea of slumping any kind of stuff on to the market has been prevalent, it is luckily killing itself by the inexorable logic of £ s. d., for the margin of values between the best and the very ordinary extract means a price either of 4s. 6d. or 2s. per pound. The next essential to absolute cleanliness is the necessity of getting the whole of the animal heat out of the fresh killed beef. The cooling chamber is a necessity and so is the regulation of the temperature of the manufactory in which the manipulation of the meat takes

place. The age and sex of the animals has a good deal to do with the quality of the extract, preference being given to bullocks three years old or a little over. It has been found that at this age the yield of extract is the best; below that age, or above it, the best results are not generally obtainable. Of course extracts can be made from veal and young animals, and with proper care they are not too gelatinous, and are nice for a change of diet. The meat being properly cooled, it is jointed and the flesh cut up into cubes, and it is important that at this stage it should not be allowed to remain long heaped up in great quantities, or a taint will develop. In 1867, Dr. Thudichum, at the meeting of the Food Committee of this Society explained the principles that make this important. The colouring matter of the muscles is called myochrome, and is identical with the colouring matter contained in the blood. Dr. Thudichum pointed out that this aids in the breathing of the muscles during life, and some time after death. As long as meat is in an eatable condition this matter remains, so to say, alive. Hence a butcher takes care to let his meat "breathe." If the meat were shut up close after being killed, it would become putrefied in a few hours. Piled up, the big heaps of imperfectly cooled minced beef would soon develop taint. The cubes of meat should be uniform in size, and this is now cut up by machinery. The meat is then put in a jacketed boiler, as I have said, with its own weight of water, the heat being raised to 175° Fahr., and it is kept stewing for about twenty minutes. It requires constant attention and stirring to prevent any possibility of burning, and the regulation of the heat must be nicely adjusted.

It is then taken out and strained, the residue is pressed and squeezed and the liquid put into a vacuum pan, and concentrated down to the desired mass, a brown pasty substance containing from 13 per cent. to 16 per cent. of water. If cooked too long in the first process, and if the albumen is not carefully strained out after coagulation, the extract will contain more moisture and the presence of albumen will deteriorate its keeping properties. The pure extract is wanted, and not a stocky, sticky, gelatinous mass. In some cases the mass after being heated is put into bags and the whole of the liquid pressed out by hydraulic or heavy pressure, so that the residue left is like nothing more than a piece of blotting paper or gun wad. There is little doubt that the latter system is the best, for the

extract then contains the full forces of the meat, whereas by the straining process a good deal is left in the residue. Some works have been rather chary, however, of adopting the latter method through fear of too gelatinous and "stocky" extract resulting. Stocky extracts are not wanted in England, and can always be made here, as they are done, in the form of jellies and soups, to which extract is added. The reason the meat is not kept at a high temperature for a long time is to prevent the decomposition of the gelatinous matter in the fibre, and its inclusion in the extract. Extracts (as shown in the table of analyses) should generally consist of about 16 per cent. water, 53 per cent. of extractive soluble in alcohol, 13 to 14 per cent. of extractive insoluble in alcohol, and 18 per cent. or more animal matter. The extract consists of inorganic and organic substances, the former being chiefly and generally alkaline phosphates and chlorides—chiefly phosphate of potash and chloride of potassium with possibly some ammonia as the base of a phosphoric acid compound. The organic parts of the extract are kreatine, or kreatinine, and gelatinous extractive. A good extract should always have an acid reaction, its colour should be a characteristic yellowish-brown, and it should have an agreeable meat-like odour and taste. It should be entirely soluble in cold water, and should be free from albumen, fat, and gelatine.

The big centres of the manufacture of extract of meat are Chicago, Buenos Ayres, Queensland (Townsville, Rockhampton, Gladstone, Bowen, Brisbane), New South Wales (Ramornie), Sydney (Meat Preserving Co.), New Zealand (Hawke's Bay—Nelson Brothers). The practical methods of manufacture are broadly on the same lines everywhere, but each centre has some little plan or convenience in operation that has been discovered in actual working, and formed the basis of some invention. A South American factory consists of a large cool dark flagged hall kept scrupulously clean. Here the meat is weighed and passed through apertures to the meat-cutting machines of special design, that can get through an incredible amount of work. Hence the meat is passed into digesters, which hold about 12,000 lbs. each, and it is "digerated," as it is termed, in a description of the commercial Liebig process, by high pressure steam, 75 lbs. to the square inch. The liquid is then run to a series of fat separators. Here the fat is separated in a hot state because no time can be lost in

cooling it for that purpose as decomposition sets in so very quickly. In clarifies below the separators, the albumen and fibrin are coagulated out, and the liquor then run into large evaporators where vacuum evaporators evaporate the extract at a very low temperature, the liquor being filtered several times before it is run into the evaporators.

In Bovril, we are told by the founder of this convenient form of putting up beef extract with other things, Mr. J. Lawson Johnston, that he hit upon a system of adding the albumen and fibrin to the beef extract in the form of a desiccated powder. Probably the success of this *bouillon* as a popular beverage was mainly to the fact that for the first time the public were enabled to buy a cup of decently made and invigorating beef tea cheaply over the counter. "Johnston's Fluid Beef" found much help in its sale at first, owing to the Scott Act in Canada, and a hot cup of Bovril was no mean substitute for hot spirits when the sale of alcoholic drinks was prohibited. Others have followed in the wake of Mr. Johnston, and have adopted packages which are similar in appearance and cannot help but be looked upon as a colourable imitation of the first popular *bouillon* on the market. It is rather a pity that the inventors of similar preparations have not struck out a new line in the shape and style of bottles and jars.

The slaughter of cattle on the River Plate and Rio Grande districts is about 2,000,000 head annually. The South American process is briefly much that which I have described above. The arrangements for slaughtering the cattle in great numbers and for dressing them with the utmost dispatch are very complete and the meat used is carefully selected. The basis of Bovril and other *bouillons* is, as we have said, the extract of beef. It is claimed, however, for this and other mixtures that the elements that coagulate in the liquid extract are restored with the manufacture of the finished article in England, and that the dried albumen and fibrin are sent over in hermetically sealed tins and worked back into the mixture here.

It is significant of the even greater development which may await the Australian trade that many of the large manipulators give preference to the finest Australasian extract, as it possesses a greater fullness and, if anything, a finer flavour than the South American.

COMPARATIVE ANALYSES OF VARIOUS FORMS OF EXTRACTS OF MEAT.

	Liebig's Process or Modifica- tions.	Bouillon.	Meat.	Jellies.
Water	16'54	29'14	89'15	51'80
Sodium Chloride ...	3'11	14'12	0'26	7'50
Other Salts	19'63	3'38	1'04	
Organic Matter	60'72	53'36	9'55	40'70
In the Organic Matter.				
Albumose	22'62	28'60	4'00	7'0
Gelatin	0'25	0'56	1'71	13'0
Flesh Bases and Decomposition Products	37'85	24'10	3'84	14'8

DISCUSSION.

Mr. G. G. MACWILLIAM said he was bound to express his obligations to the reader of the paper for the information he had given, and for the very interesting views he had shown. Although he had existed upon the extract, he did not know there was such gigantic machinery employed in its production; and certainly those who had perfected the process deserved the warmest thanks of all who did not care for heavy feeding. It was a very important industry in the colonies so far as he could gather from the various companies already existing, and judging from some others which were about being formed the trade was going to be much larger. He was glad of it, for there never was a time when soup could be so nicely and generously made as at the present day, thanks to these admirable extracts. This industry would be largely developed ere long in other countries besides New South Wales, Queensland, and New Zealand. The grazing capacities of West Australia were being rapidly increased, and Queensland would find there a strong competitor. From Albany up as far as Wagga he felt sure that in five years time there would be a considerable number of factories erected because the cattle would by that time be very largely increased. They need not be alarmed at that, however, for the public inclination not only in England but in other countries was to make more and more use of this excellent addition to the food supply.

Mr. JOHN M. DONALDSON (Messrs. Armour and Co.) said he also desired to express the pleasure he had experienced in listening to this paper. In talking of the care which was exercised in the manufacture in order to ensure purity, Mr. Valentine might have referred to the difficulties encountered by those who endeavoured to maintain a high standard in the face of competition by those who were less scrupulous. Many of them would like to see meat extract included in the list of articles to be dealt with by the Adulteration Bill now under consideration. It seemed to him that all articles of food, whether

carefully corked and capsuled or sold loose, should be subject to analysis, and a high standard of purity maintained, otherwise their usefulness would be lost and public faith in them would cease.

The CHAIRMAN said he thought probably the most important part of the paper was the strong recommendation that the extract itself should be made in the colonies and sent to Europe without any admixture of gelatine, fibrous material, or other things which might be enumerated, the mention of some of which might not be very agreeable. Beef was distinctly better for the purpose than mutton for many reasons; the melting point of mutton fat being an insuperable objection to making the best quality of extract from it. The important point was that the pure extract of meat should be sent over and afterwards certain things might be added which would make it more useful for dietetic purposes. He might remind them that properly made extract of meat administered to the human subject was of extreme value, but it could not properly be termed a food. It was in the nature of a nerve stimulant, and might be given to the human machine when working quietly, underworked rather than overworked. In dealing with a community that had to use either its brains or its muscles, extract of meat was no more food than alcohol, by itself; it required to have something mixed with it which gave more force than the mere stimulating action of the soluble constituents of flesh, which were largely saline matters. There were a number of excellent preparations for that purpose, and the results were promising, though he must say that he had found some of the most vaunted preparations of the least value. That might be due to the fact that the necessary amount of fibrous or gelatinous material to be added had not yet been exactly ascertained. The moment that you added to the extract any of these less easily digested substances you raised the temperature of the machine, gave it more work to do and got power out of it. He believed it would be possible to make a preparation from beef which would give practically all the power which could be got out of roast meat, but it would not be done in a moment. The facility with which good extract of meat could be made, the advantages of easy division or dosage, so that a single cup of *bouillon* or beef tea could be made at a moment's notice, and even cold water would do if you could not get hot, was a considerable step. If you had a perfect extract to begin with, and were able to add to it a sufficient amount of that material which went most largely to the formation of muscle—by which he did not mean glue, but a form of gelatine and of nitrogenous material, which was much more easily digested than glue—then you would have a preparation which would be of the greatest possible value as a food. He was not sure that in the case of those who had to get their living more by their brains than by physical work such a preparation would not be the best form of getting into the system

the nitrogen required. When you came to athletic sports and hard outdoor work, the power of digesting other things came into play, and one could digest what in future would perhaps be termed a comparatively crude diet; but for those in big cities who had to use their brains much and work against time, such preparations would undoubtedly be of the greatest possible value. He would also like to give a note of warning with regard to the deterioration which had been referred to, for it would be a great misfortune if the nutritive value of the preparation were diminished in the attempt to put it on the market at the lowest possible price. He would conclude by proposing a hearty vote of thanks to Mr. Valentine, who had been exceedingly modest as to his own part in the work.

The vote of thanks having been carried unanimously,

MR. VALENTINE, in reply, said it had been a great pleasure to him to prepare the paper, and he hoped it might be of some use in putting the extracts of meat from the colonies on a better footing as to quality. He had not mentioned Western Australia, Victoria, South Australia, or Tasmania, because he had only dealt with those colonies in which the production was being largely carried on at present, but he was quite conversant with the facilities which the other colonies possessed. One great object in bringing forward the Australasian colonies was to show that they had the means of supplying this raw material on the cheapest possible basis. In the United States he could not but think that the rapidly-increasing population would soon consume a much larger proportion of the output. He fully endorsed what had been said about adulteration, and was convinced that if the law were applied to these extracts it would give the high-class manufacturers a much better chance. He must say, from the very prominent advertisements which appeared about the blending of certain materials with others to increase their nutritive value, that some of the statements made were altogether unwarranted. His view was that the exportation from the colonies should be confined to the "*extractum carnis*," as anything which required to be added could be obtained and manipulated better in this country. His opinion was that the extract was a "*pick-me-up*," and about the best oil one could apply to grease the wheels of the human machine.

Obituary.

SIR HENRY BESSEMER, F.R.S.—Sir Henry Bessemer, whose name is so intimately associated with the manufacture of steel, died on Tuesday evening, 15th inst., in the 86th year of his age. He was elected a member of the Society of Arts in 1850, and he became a member of the Council in 1872, the year in which he was awarded the Albert Medal "for the eminent services rendered by him to Arts, Manufac-

tures, and Commerce, in developing the manufacture of steel." In 1885, also, the Council of the Society awarded him a gold medal in connection with the International Inventions Exhibition, for the invention of Bessemer steel.

Bessemer was born on January 19, 1813, at Charlton in Herts, and early showed a taste for mechanical invention. About the period of the Crimean War he directed his attention to the subject of gunnery, but after a time he came to the conclusion that it was useless to work on the projectiles until the guns themselves had been rendered stronger and better, and he therefore applied himself to the study of metal for artillery purposes generally. After several years' devotion to these investigations, he hit upon the central principle of the Bessemer process for the conversion of cast iron into cast steel, and in 1856 he read before the British Association at Cheltenham his first paper on his discovery of the means of rapidly converting pig-iron into steel by blowing a blast of air through the iron when in a state of fusion. But many difficulties had still to be overcome, and it was only after Bessemer had himself opened works at Sheffield, and made steel by his process, that the opposition was finally broken down. The after development of the great Bessemer process, and its revolutionary effect on the manufacture of iron and steel, are well known, and need not be recorded here. It may, however, be mentioned that the output of Bessemer steel for the year 1896 over the whole world was calculated at 11,000,000 tons, 7,000,000 tons being made by the more recent Siemens' process.

In 1859 the Institution of Civil Engineers awarded him a gold Telford Medal for a paper on his process. In 1871-3 he was President of the Iron and Steel Institute, and founded a gold medal to be given annually for the most important improvement of the year in the manufacture of iron and steel.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock :—

MARCH 30.—"Telegraphy Across Space." By Professor SILVANUS P. THOMPSON, F.R.S. J. W. SWAN, F.R.S., will preside.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock :—

MARCH 31.—"The Earthquake in Assam." By HENRY LUTTMAN-JOHNSON, I.C.S. Sir DENNIS FITZPATRICK, K.C.S.I., formerly Chief Commissioner of Assam, will preside. (At the Imperial Institute.)

APPLIED ART SECTION.

Tuesday Evenings, at Eight o'clock :—

MARCH 29.—"English Art in Illuminated MSS." By Sir EDWARD MAUNDE THOMPSON, K.C.B. Sir JOHN EVANS, K.C.B., D.C.L., Treas. R.S., will preside.

CANTOR LECTURES.

Monday Evening, at Eight o'clock :—

MARCH 28.—PROF. W. NOEL HARTLEY F.R.S., "The Thermo-Chemistry of the Bessemer Process." Lecture III.

MEETINGS FOR THE ENSUING WEEK

MONDAY, MARCH 28...SOCIETY OF ARTS, John-street Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. W. N. Hartley, "The Thermo-Chemistry of the Bessemer Process." (Lecture III.)
Sanitary Institute, 74A, Margaret-street, W., 8 p.m. Dr. J. Priestley, "Ventilation, Warming, and Lighting."
Scottish Society of Arts, 117, George-street, Edinburgh, and Commercial Aspects and Imperial Importance."
burgh, 8 p.m. 1. Report on (a) Mr. Peebles' paper on "Acetylene Gas and Apparatus for its Production;" (b) Mr. P. Whyte's paper on "Hydraulic Machinery at Leith Docks." 2. Mr. G. K. Griev, "The Comparative Cost of Gas and Electricity as Sources of Light, Heat, and Power." 3. Mr. Shaw, "Electric System of Mechanical Ventilation."
Imperial Institute, South Kensington, 8½ p.m. Messrs. John Ferguson and J. Davis-Allen, "The Projected Indo-Ceylon Railway."
Geographical, University of London, Burlington gardens, W., 8½ p.m.
Actuaries, Staples-inn-hall, Holborn, 7 p.m.
Medical, 11, Chandos-street, W., 8½ p.m.
TUESDAY, MARCH 29...SOCIETY OF ARTS, John-street Adelphi, W.C., 8 p.m. (Applied Art Section.) Sir EDWARD MAUNDE THOMPSON, "English Art in Illuminated MSS."
Royal Institution, Albemarle-street, W., 3 p.m. Professor E. Ray Lankester, "The Simplest Living Things." (Lecture XI.)
Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. E. W. Stoney, "Extraordinary Flood in Southern India: their causes and destructive effects on railway works."
Anthropological, 3, Hanover-square, W., 8½ p.m.
WEDNESDAY, MARCH 30...SOCIETY OF ARTS, John-street Adelphi, W.C., 8 p.m. Professor SILVANUS P. THOMPSON, "Telegraphy Across Space."
United Service Institution, Whitehall, S.W., 3½ p.m. Capt. J. N. C. Kennedy, "Wireless Telegraphy."
THURSDAY, MARCH 31...SOCIETY OF ARTS (East Conference Hall, Imperial Institute) 4½ p.m. (Indian Section.) Mr. Henry Luttman-Johnson, "The Earthquake in Assam."
Antiquaries, Burlington-house, W., 8½ p.m.
Chemical, Burlington-house, W., 8 p.m. Annual General Meeting.
Royal Institution, Albemarle-street, W., 3 p.m. Prof. J. A. Fleming, "Recent Researches in Magnetism and Diamagnetism." (Lecture V.)
Sanitary Inst., 74A, Margaret-street, W., 8 p.m. Mr. E. T. Hall, "Sanitary Building Construction."
FRIDAY, APRIL 1...Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Prof. Dewar, "Liquid Air as an Analytic Agent."
Geologists' Association, University Col. W.C., 8 p.m.
Philological, University College, W.C., 8 p.m.
Quekett Microscopical Club, 20, Hanover-square, W.C., 8 p.m.
SATURDAY, APRIL 2...Royal Institution, Albemarle-street, W., 3 p.m. Mr. Lionel Cust, "Portraits as Monuments." (Lecture II.)

Journal of the Society of Arts.

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FRIDAY, APRIL 1, 1898.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****CANTOR LECTURES.**

On Monday evening, 28th ult., Professor W. NOEL HARTLEY, F.R.S., delivered the third and concluding lecture of his course on "The Thermo-Chemistry of the Bessemer Process."

On the motion of the CHAIRMAN, a vote of thanks to the lecturer was carried unanimously.

The lectures will be printed in the *Journal* during the summer recess.

APPLIED ART SECTION.

Tuesday, March 29, 1898; Sir JOHN EVANS, K.C.B., D.C.L., Treas. R.S., in the chair.

The paper read was "English Art in Illuminated Manuscripts," by Sir EDWARD MAUNDE THOMPSON, K.C.B., D.C.L.

The report of the meeting will be published in the next number of the *Journal*.

COMMITTEE ON ACETYLENE GAS GENERATORS.

The Orders in Council regulating the use of calcium carbide and of acetylene gas (when the gas is under high pressures or liquefied) do not legislate for apparatus in which gas is generated from the carbide at low initial pressure, and of these there is now an immense variety before the public. Whilst the majority of such generators may be, and doubtless are, absolutely safe with ordinary precautions, yet some of them may, from want of adequate scientific knowledge of the properties of calcium carbide and of acetylene gas, be so constructed as to constitute a very serious danger in the hands of unskilled labour, and it is chiefly where unskilled labour is employed that the new illuminant now meets with the largest demand.

The Council of the Imperial Institute have authorised the holding of an Exhibition of Acetylene Gas Apparatus in the grounds of the Institute at an early date, and in order to ensure that no apparatus should be admitted to the Exhibition unless it was shown to fulfil the requisite conditions of safety, the Council of the Society of Arts have appointed a Committee to decide upon those conditions, and to lay down rules for the admission of apparatus.

The following gentlemen have been appointed to act on this Committee:—Major-General Sir Owen Tudor Burne, G.C.I.E., K.C.S.I. (Chairman of the Council); Sir Frederick Bramwell, Bart., D.C.L., F.R.S.; Prof. James Dewar, M.A., F.R.S.; Harry Jones, M.Inst.C.E.; Prof. Vivian B. Lewes; Prof. Boverton Redwood; Prof. W. C. Roberts-Austen, C.B., F.R.S.; Prof. J. M. Thomson, F.R.S.; Sir Henry Trueman Wood (Secretary).

The Committee has held two meetings, and have generally decided as to the conditions which the apparatus should be required to fulfil.

Full particulars will shortly be issued as to the regulation and rules laid down.

Proceedings of the Society.**FOREIGN AND COLONIAL SECTION.**

Tuesday, March 15, 1898; Sir ALBERT ROLLIT, M.P., LL.D., in the chair.

The CHAIRMAN, in introducing Mr. Neville Lubbock, said he was the very highest authority upon the particular subject with which he was about to deal. It had been his good fortune to hear Mr. Lubbock address audiences on this subject frequently, the first time being some 15 or 16 years ago in Hull. That was the commencement of a crusade which he hoped was drawing near to a favourable conclusion. Apart from what the ultimate effect of that campaign might be, the result was one from its economical aspect which was of the very greatest interest. He need not remind the meeting that from a sympathetic point of view the feeling of this country must inevitably go towards our very old colonies, in which a very large amount of disadvantages had recently been incurred in consequence of a system on the part of other countries which no one of authority had attempted to defend. Whether the bounties were on sugar or on ships, or on the men to man those ships, or aught else, it seemed to him that it was a source of injury to the country which allowed them, and an injustice to the countries against whom they were practically allowed. Those were subjects which would be spoken of with

great weight, and he was sure with great impartiality by Mr. Lubbock.

The paper read was—

THE WEST INDIES AND SUGAR BOUNTIES.

BY NEVILLE LUBBOCK.

The question of sugar bounties is once again attracting public attention for the fourth time in the last twenty years, if my memory serves me rightly. The reason this question has again come to the front is, as you know, the serious condition of our West Indian Colonies. I propose in this paper to give you some account of the present condition of the West Indies, and to add a few words on the subject of the sugar bounties.

Towards the end of 1896 representations began to pour in upon the Colonial Office, from those interested in the West Indies, to the effect that there was danger of a large reduction in the sugar industry of those colonies, and that the result of this would be extremely serious. Mr. Chamberlain was so much impressed that he felt he was no longer justified in allowing matters to take their own course, and that action of some sort had become a necessity.

On Nov. 9, 1896, he accordingly addressed the following letter to the Treasury:—

“Downing-street, Nov. 9, 1896.

SIR,

“(1.) Representations continue to reach Mr. Secretary Chamberlain, giving cause for increasing disquietude as to the prospects of certain West Indian and other sugar-producing colonies.

“(2.) The Lords Commissioners of the Treasury are aware that the price of sugar in open markets has for some time past been affected by extraordinary depression, caused both directly by the bounties given by some European Governments and indirectly by the effect of those in stimulating an enormous production in advance of an effective demand.

“(3.) Early in the year 1895 it was judged necessary by the Marquis of Ripon to sanction special remission of taxation on sugar estates in British Guiana, Trinidad, and the Leeward Islands, in consequence of the evidence laid before him of the critical position of this industry. In the course of that year very urgent petitions and memorials were addressed to the Secretary of State from practically all the colonies affected, through their Chambers of Commerce and other associations, making positive statements as to the disastrous effect of the position of the sugar trade in the abandonment of estates and the disorganisation of the industry. These representations were endorsed and supported by the Governors. In November, 1895, Mr. Chamberlain

was addressed by a very large and representative deputation on behalf of the West India sugar industry, and the commercial and engineering interests associated with it, who desired that he should recommend Her Majesty's Government to take active steps against the foreign sugar bounties as the only means of saving the West Indian Colonies from ruin.

“(4.) On the 1st of August last the amounts of the bounties offered by the Governments of Germany and Austria-Hungary were approximately doubled, and a Bill has been prepared, and will probably be adopted in France, to raise the bounties in that country correspondingly, although it is computed that they are even now equivalent to a grant of £3 5s. per ton. The new German rates are from 1s. 3d. to 1s. 9d. per cwt., or 25s. to 35s. per ton.

“(5.) The prospect created by the announcement of these increased rates caused a renewed fall of about £3 per ton in the market price of sugar, and has resulted in a fresh series of memorials to the Secretary of State, and in a stimulus to the tendency to abandon the cultivation of estates. Announcements of the intention to do this, and warnings as to the serious consequences that may be expected, are reaching Mr. Chamberlain from most of the colonies affected.

“(6.) These facts are very briefly recapitulated without detail, which would be superfluous in view of the position which Mr. Chamberlain has so far been forced to maintain towards all such representations, namely, that Her Majesty's Government do not see their way to take any effectual or active steps whatever to countervail the operation of the bounties.

“(7.) Until recently, it appeared not impossible that the continental bounties might be spontaneously withdrawn, or that the over-production which they have caused might remedy itself in the natural way by the collapse of unprofitable businesses. These possibilities are adjourned by the increase in the bounties above alluded to.

“(8.) Mr. Chamberlain feels that he cannot any longer disregard indications which are arising in the administrative purview of this department of impending liabilities and difficulties which the colonies will not be able to meet unaided.

“(9.) At the end of the year 1895 there were deficits in Antigua and St. Kitts of £26,000 and £16,000 respectively; and, notwithstanding an unusual heavy sugar crop in those islands and an increase in the rates of taxation, it is expected that these deficits will be increased during the current year. The population are almost entirely dependent on the sugar estates, and it is represented that estates are being abandoned. There were riots in St. Kitts this spring arising from the reduction of wages on the sugar estates, and if there is any serious reduction of employment a recurrence of disturbances may be expected. The Windward Islands have during 1895 and 1896, notwithstanding severe retrenchment and the increase of taxation until the point of inelasticity

has been reached, fallen into a state of insolvency which compels Mr. Chamberlain to apply to the Lords Commissioners for an imperial grant in aid, as to which another letter will be addressed to you. The Lords Commissioners will recollect that in the letter from this department of the 15th of August last, in which Mr. Chamberlain applied for assistance in promoting subsidiary industries, which the Lords Commissioners decided not to grant, the possibility that such an appeal might become necessary was foreshadowed. The abandonment of the majority of the sugar estates in St. Vincent has been definitely announced.

"(10.) The Government of Barbados has been passing through severe financial difficulties, involving reductions of the cost of establishments. The effect of the abandonment of estates in this island would be particularly grave and would necessitate assisted emigration.

"(11.) With regard to some of these colonies there may be reason to think that improvements in manufacture have been neglected. This, however, cannot be said to be the case in Trinidad, where, nevertheless, cultivation is being reduced; nor in British Guiana, where it is being reduced with very serious rapidity, involving the loss of much capital invested in expensive machinery.

"(12.) This process has a special significance in the two last-named colonies, the Governments of which are responsible for many thousands of coolie immigrants, which they are liable to be called upon, under contract, to repatriate. If sugar cultivation, for which British Guiana and Barbados are specially suitable, and in which a large amount of capital is invested, were abandoned in those colonies, no alternative industry could at once take its place, and the coolies in British Guiana and the negroes in Barbados would be thrown on the hands of an insolvent administration, which would be unable to provide for their repatriation in the one case and for their support or emigration in the other case. The circumstances of Antigua, St. Kitts, and Nevis are analogous on a smaller scale.

"(13.) The special danger which appears in the outlook in the colonies thus dependent on sugar lies in the fact that this industry employs far more labour to the acre than any possible substitute, and that no substitute is immediately available; that the revenue depends directly on the industry, and that the administrations are therefore liable to be financially crippled just when there is the greatest strain on them, and that any general failure of employment may be confidently expected to produce, if not immediate rioting, at least a very dangerous and unstable situation in which more efficient police arrangements than exist in the majority of the islands, and possibly the presence of troops or ships of war, may be necessary to maintain order.

"(14.) A serious plantation disturbance, involving a large number of casualties, has been reported from British Guiana by last mail.

"(15.) It must also be borne in mind that the colonial banking establishments in the West Indies are considerably involved in the sugar industry, and that a collapse of that industry would be likely to bring about a financial crisis, the gravity of which and of its indirect consequences it would be difficult to estimate.

"(15.) The foreign sugar bounties have been, and are at present, of substantial advantage to some of the industries of this country. It was in a great measure on this account that the Bill introduced by Her Majesty's Government, in the year 1889, to give effect to the Sugar Bounties Convention was not pressed. It has now, in view of further developments, become a question whether the continued enjoyment of this advantage does not involve the ruin of the British sugar-producing colonies, and if so, what this prospect further implies, both as regards the social future of such colonies and in claims for Imperial expenditure which it will not be possible to resist.

"(17.) The position of affairs being as indicated, Mr. Chamberlain is not prepared, as Secretary of State for the Colonies, to accept the responsibility of allowing matters to take their course, and to acquiesce in the policy of non-intervention hitherto pursued in regard to bounties without having satisfied himself as to what such policy may entail, as regards both the colonies and the Exchequer, nor would he think it right that Her Majesty's Government should adhere to their present attitude on this question without knowing, as clearly as possible, at what cost it may be to the welfare and stability of an important part of the Empire, and to industries in which English capital is largely invested.

"(18.) Mr. Chamberlain has, therefore, come to the conclusion that it is expedient that a Royal Commission shall be appointed to inquire into the effect of the foreign sugar bounties upon the British colonial industry, more particularly in regard to the West Indies, as early as can be arranged, so as to investigate in the colonies themselves whether their position has improved or retrograded during the last ten years, and the causes involved; what are actually the state and prospects of the sugar industry, and of any alternative industries existing or possible to be established, and what has been the course of, and what causes have affected, the revenue and expenditure of the Governments of late years; what is the condition and temper of the negro and coolie populations; and what line of industrial development it is likely that these populations may follow with advantage in the event of the extensive abandonment of sugar estates.

"(19.) There are many particulars of inquiry subsidiary to these main heads which would come within the scope of such a Commission; the precise terms of reference may be determined if the appointment of the Commission is decided upon.

"(20.) Mr. Chamberlain desires me to request that you will move the Lords Commissioners of the Treasury to give their serious consideration to this

proposal, which has not been made without mature deliberation on a long succession of circumstances conducing to suggest its necessity."

As the result of this communication, a Royal Commission was, as you all know, appointed, consisting of Sir Henry Norman, Sir Edward Grey, and Sir David Barbour. These gentlemen visited the West Indies; they made most searching inquiries, took an enormous amount of evidence, and finally presented their report in August of last year. This report fully confirms the representations which Mr. Chamberlain had made to the Treasury as to the critical position of these colonies.

The Commissioners say:—

"The distress will be due to the failure of the sugar industry, which is, in turn, partly due to the protective policy of other countries and to the bounties which some of them grant on the production or export of sugar. To some extent, at any rate, these bounties and this policy have made sugar cheaper outside the countries in question, a result by which the British consumer has gained very largely. Whilst, therefore, it is unfair to say that the cause of the depression in the West Indies is due to any act of the British Government, we cannot overlook the fact that the British people have been reaping great benefit from precisely that set of circumstances which has been a factor in bringing the West Indies to the verge of serious disaster."

The consequences of a failure of the sugar industry are described by the Commissioners as follows:—

"(39.) If such reduction or extinction of the industry occurs, and if its place cannot be adequately filled by the substitution of other industries, the consequences are likely to be of a very serious character.

"(40.) The immediate result would be a great want of employment for the labouring classes, and the rate of wages, which have already fallen, would in all probability be still further reduced. The public revenue would fall off, and the Governments of some of your Majesty's possessions would be unable to meet the necessary public expenditure, including interest on debt, whilst additional outlay would have to be incurred in providing for the population by emigration or otherwise, and the general standard of living would be reduced to a lamentable extent in every colony which is largely dependent on sugar.

Par. 41 only refers in detail to some of the colonies.

"(42.) In British Guiana and Trinidad the necessity for keeping faith with the East Indian immigrants, and of repatriating those of them who had a right to a free passage to India, and wished to take advantage of that right, might involve a large expenditure, which, under the circumstances, must fall upon the

public funds, as it would be impossible to levy the sum from the sugar estates.

"(43.) The present condition of such an island as Tobago illustrates the serious character of the economic and administrative problem that must arise in your Majesty's possessions in the West Indies if there is a collapse in the sugar industry. The exports of sugar from Tobago have already decreased very much. The resident population manages to live, but a considerable proportion of them are driven, permanently or temporarily, to other islands in search of work, and it is impossible to raise more revenue than is barely sufficient to meet the necessary expenditure on the cheapest and simplest form of government. New roads cannot be made, and even those that already exist cannot be kept in proper repair out of revenue."

With regard to a remedy the Commissioners all agreed that the only complete remedy was a rehabilitation of the sugar industry. With a view to this end they all advised that the aim of Her Majesty's Government should be the abolition of bounties; and Sir Henry Norman further advised that, if necessary to secure this result, countervailing duties should be levied on bounty-fed sugar to an amount equal to the bounty.

The Commissioners made a number of other recommendations with a view of stimulating minor industries, but I think they would probably all agree with Sir Henry Norman that:—

"The tenor of the evidence, the conclusions of the Report and the paper of Dr. Morris, than whom there is no higher authority on West Indian production, must satisfy any one that it is impossible to expect that any industry or industries can within any reasonable time replace sugar, whether as affording employment and subsistence to the people, or as enabling revenue to be raised to maintain the administration."

Sir Henry Norman concludes his minority report as follows:—

"There seems to be no measure except the imposition of countervailing duties, which is likely to save a considerable group of British colonies from serious disaster, or prevent obligations falling on the mother country, which will be very onerous and very difficult to meet in a satisfactory manner."

I wish to call your attention to the last words, "obligations falling on the mother country, which will be very onerous and very difficult to discharge in a satisfactory manner." Therein lies the hope of the West Indian Colonies. I will only here remark that whilst the obligations are described as very onerous, the Commissioners avoided answering the question as to what these obligations are likely to amount to.

And now what are the objections to countervailing duties? Countervailing duties are levied upon spirits, upon chicory, and upon cigars: why not upon sugar? Let us see what Sir Edward Grey and Sir David Barbour have to say. Their objections are summed up in paragraph 82 of the Report as follows:—

“(1) The loss to the British consumer that would result from any rise in the price of sugar; (2) the inconvenience to trade that would be caused by the imposition of countervailing duties; (3) the uncertainty whether any such measure would permanently save the sugar industry in the West Indies; (4) the inexpediency of raising questions connected with the interpretation of the most favoured nation clause; and (5) the danger, direct or indirect, of departing from what has hitherto been considered to be the settled policy of the United Kingdom.” They add, however, “At the same time we consider it to be our duty to draw attention to the precarious condition of the sugar industry in the West Indies, to the very serious consequences to the colonies which must result from a failure of that industry, and to the fact that the levy of countervailing duties is practically the only remedy pressed upon us by the witnesses we have examined which rests in the hands of Your Majesty’s Government.”

Let us examine each of these points.

1. *The loss to the British consumer which would result from any rise in the price of sugar.*—This would be a valid argument against the abolition of bounties, which—however brought about—would of course raise the price of sugar to the same extent as the countervailing duty; but Sir E. Grey and Sir D. Barbour strongly urge that bounties should if possible be abolished. Again, they profess doubts whether countervailing duties would raise the price of sugar permanently (paragraphs 73-74); but, if it did, they agree (paragraph 70) that “on the whole we think, as we have already indicated, that the loss to the British consumer, if it were the only matter to be considered, might reasonably be accepted in view of the importance of removing the disadvantage under which the West Indian producers at present labour.” And, in paragraph 51, they agree to an even stronger expression of opinion, viz., “the benefit which the British Empire as a whole derives from any lowering of the price of sugar due to the operation of the bounty system is too dearly purchased by the injury which that system imposes on a limited class, namely,

Your Majesty’s West Indian and other subjects dependent on the sugar industry.”

2. *The Inconvenience to Trade.*—I can speak with some experience of sugar duties, and I do not hesitate to say this is a myth. For some 25 years after I went into business, heavy duties were levied on sugar, and no inconvenience whatever was found. Moreover, it is obvious that countervailing duties would never actually come into force. Once let the Queen in Council have power to impose countervailing duties, and bounties will at once disappear. A moment’s consideration must make this obvious. Why are bounties given? No one, I presume, is so naïve as to imagine that it is to benefit us. They are given solely with a view to give the industries receiving them an artificial advantage over their competitors in the open markets of the world; and the open markets of the world are now synonymous with the markets of Great Britain and Ireland and her colonies and dependencies. If this artificial advantage were removed, or even if we made it clear that we intended to remove it, it would at once disappear. It is out of the question to suppose that foreign Governments would continue to give bounties if their only effect were to relieve the British taxpayer by a contribution to the British revenue.

3. *The uncertainty whether such a measure would permanently save the sugar industry of the West Indies.*—This is, of course, a matter of opinion. Let us see what the unanimous opinion of the Commissioners themselves is on this point. In paragraph 54 they say:—

“So far as we are able to form a judgment on the question, we are of opinion that the abolition of the bounty system on the Continent would render it possible, under present conditions, to maintain profitably a large proportion of the present area of sugar-cane cultivation.”

There is really no doubt about it at all. The price at which sugar can be produced in the West Indies is well within the price at which the British consumption can be provided for under Free Trade.

4. *The inexpediency of raising questions connected with the favoured nation clause.*—This is a legal question, and must be considered. In 1879 we took the opinion of Prof. Sheldon Amos and Mr. Shepherd on this point, and this is the conclusion they came to—the whole of the opinion is too long to quote here. After defining the term bounty they say:—

"An exporter from a foreign country receiving such a bounty becomes an importer into this country, possessing a tariff or fiscal advantage over other importers not enjoying a bounty. This seems such an obvious economic consequence that we are entitled to assume it as such without discussing purely economic points.

"Although this tariff advantage is not created by the importing State, yet it can only be enjoyed by the foreign exporter upon sufferance of the importing State, therefore such tariff advantage virtually depends upon the negative action of the importing State.

"We also assume that the countervailing duty to which our opinion is to apply, is a duty which shall correspond in amount to the bounty as defined. We further assume that if such a bounty as defined is met by such a duty as defined, the importer enjoying such a bounty, but liable in consequence to such a duty, is thereby in no different fiscal position to an importer enjoying no bounty and paying no duty."

They then take our commercial treaty with Austria, which contains the usual favoured-nation clause, and, after quoting this, they say:—

"The result, then, of these respective obligations can only be obtained by the produce of each of the several exporting countries being admitted on terms of fiscal equality into this country. If, therefore, one of such exporting countries destroys this equality by giving a fiscal advantage, which it is within the power of this country to neutralize, we consider that the interpretation of this clause would favour rather than preclude the exercise of such power.

"Independently of all treaties, each country has full power to deal with importations from other countries on any terms it pleases, to exclude some and to favour others. The favoured-nation clause is a restriction upon this power, in order to bring about equality of fiscal conditions between the importers from either treaty Power and importers from third countries into the territories of the other treaty Power.

"Moreover, it is clear that the articles of a treaty of commerce are directed to the interests of classes of the subjects of the respective sovereign Powers in their several characters as importers, exporters, &c. Therefore, the injurious operation of any State tariffs or fiscal arrangements upon importers, exporters, &c., in their respective characters as such, raises a proper question under the treaty. And, in our opinion, it is not the less a treaty question because it may happen that the fiscal action which prejudices some one class of citizens in their treaty characters may benefit some other class. Therefore, we are of opinion that imports of sugar into this country may, without contravening the favoured-nation clauses of existing commercial treaties, be distinguished as to countries of origin wherein bounties on export are or are not obtainable, and a countervailing duty levied on sugar imported from countries where export bounties are obtainable, whilst

sugar from all other countries is admitted duty free. This construction is consistent with the fact that the Sugar Convention of 1864 between Great Britain, France, Holland, and Belgium contained an article admitting the principle of the imposition of a differential surtax against countries not parties to that convention giving export bounties, notwithstanding that, at the date of that convention, this country was bound by treaty with Russia to admit her products at 'no other or higher duties than are or shall be payable on the like article, the growth, produce, or manufacture of any other foreign country.'

"Moreover, notwithstanding such article in the Convention of 1864, favoured-nation clauses were contained in the commercial treaties entered into during the period of ten years for which that convention was in force; and such favoured-nation clauses must be held as subject to the treaty engagements under which, during such period, Great Britain was subject by that Convention of 1864.

"In conclusion, we beg to state that our opinion is based upon the broad principle that equality of fiscal condition, as between either treaty Power and any third country the most favoured by the other treaty Power, is the object of favoured-nation clauses, and that the one who destroys such equality cannot appeal to the treaty against the Act necessitated to reinstate that equality.

"(Signed), SHELDON AMOS, of the Inner Temple
"Barrister-at-Law.

"(Signed), WALLWYN POYER B. SHEPHEARD,
"of Lincoln's Inn.
"Barrister-at-Law."

5. The danger direct and indirect of departing from our settled policy.—Now I should have thought that if we have a settled policy in this country, that policy was Free Trade. Is there any pretence on the part of anyone that we have Free Trade in sugar as long as bounties continue. Even Lord Farrar admits that bounties are an abomination, and that we must all desire their abolition. Once the principle of countervailing duties is accepted they will be at once abolished, and Free Trade will obviously be restored. What is Free Trade? Is it not the absence of any artificial advantage to one producer over his competitor? In this case it is true the advantage to the foreigner is given by foreign Governments, but it operates in our markets, and we are responsible for permitting it to continue to the injury of our own producers. I confess I am utterly at a loss to comprehend the frame of mind of those who admit that bounties are contrary to Free Trade, but dub as Protectionists those who seek to remove them.

Now I have given you the reasons, I believe quite faithfully why Sir E. Grey and Sir D. Barbour think it would be wiser to allow the West Indies to be ruined and their population of some 2,000,000 persons reduced many of them to a state not much removed from starvation, rather than impose countervailing duties, and this in the face of the fact that they urge Her Majesty's Government to aim at the abolition of the bounties, although condemning the only means by which it is in the power of Her Majesty's Government to bring about this result.

I have now taken you shortly through the history of the sugar bounty question as it affects our West Indian Colonies. I am not here to-day to discuss the cases of Mauritius and Queensland, but I may say that they also are suffering severely from the same cause as the West Indies. And now I wish to add a few words as to the effect of these bounties on our home interests.

In Mr. Chamberlain's letter to the Treasury there is one statement which I venture to say is very largely exaggerated. In paragraph 16 Mr. Chamberlain says: "The foreign sugar bounties have been and are at present of substantial advantage to some of the industries of this country." I maintain that this is an entirely erroneous assertion. It has, however, been so frequently stated and so persistently put forward in the Press, and appears on the face of it so plausible, that Mr. Chamberlain may readily be forgiven for assuming its correctness. But it is on this account the more important that its fallacy should be exposed, and I therefore ask your patience to bear with me for a few moments whilst I try to make this clear to you.

I may at once say that I do not doubt that the lower the price of sugar, so much the better for consumer, whether such consumers are manufacturers or not. But the case we have to deal with is this. Since 1884, or say during the last thirteen years, there has been a fall in the price of sugar, speaking in round figures of about £10 per ton. Of this fall not one penny has been due to the bounties. The effect of bounties on the price of sugar must have been felt long before 1884, and it is the reduction of £10 per ton which has taken place since then that has been of substantial advantage to our jam makers: but this has not been due to bounties except in so far that if bounties had been removed in the meantime the fall would probably have been £9 instead of £10 per ton. But it is obvious that a question of

£1 per ton cannot be accurately described as a substantial advantage to our jam and confectionery trades. In connection with this phase of the question there is an idea that the abolition of bounties will so raise the price of sugar that these industries will be seriously injured. And a portion of the Press has got another very curious idea, viz., that although these industries would not be affected by a rise of price due to the abolition of bounties if this abolition of bounties arose from the spontaneous action of foreign Governments, they would be fatally injured by a similar rise in price if it resulted from the action of the British Government in deciding to impose countervailing duties. Now, I think I need hardly point out that whether bounties are abolished spontaneously or by countervailing duties, the result of the abolition on the price would be absolutely identical; consequently, the effect on the industries concerned would be the same in either case, and this effect, I am now going to show you, would be nil.

Let me say a word to you about price before I go further. A good deal is said in the Commissioners' report on this subject; but it is almost impossible to understand what they really intended to convey, as they do not define anywhere what price they are alluding to. You know that prices vary from day to day, from month to month, and from year to year. Now, to an industry like the jam industry the price that concerns them is the average price they pay over a prolonged period. The price that this industry has had to pay for sugar on the average of the last twelve years has been on the basis of £13 per ton for what is called 88 per cent. beet. I will explain this. There are, of course, a variety of qualities of sugar, but they all practically rise and fall together in proportion, and beet sugar of the quality known as 88 per cent., being one of the qualities most largely dealt in, is a convenient basis of measurement upon which to compare the rise or fall of the price of sugar generally.

Now comes the question. If bounties are abolished, how much more will the jam makers have to pay for their sugar during the next twelve years? The Commissioners practically admit that the abolition of bounties would raise the price temporarily by about £1 per ton, but then arises the question—raise it from what? Did they mean from £13? Certainly not. There are many passages in this Report which clearly prove this. I believe that what they meant was that the abolition of bounties would raise the price of sugar £1 per ton above the

price then ruling. This price was 8s. 9d. per cwt. (£8 15s. per ton), so that, if I have rightly construed their view, the jam makers would in future have to pay 9s. 9d. per cwt., or £9 15s. per ton for their sugar. I confess I do not agree with this view myself. I should have put the probable future price, if bounties are removed, at £11 per ton, and this is the view taken by our practical men of the largest experience in the sugar industries of the world. Now, assuming that I am right—and remark that the Commissioners' view is much more favourable to my argument than my own—is it likely that the jam makers who have prospered to an extraordinary extent with an average price of sugar of £13 per ton are to be seriously injured by having to pay £11 per ton in the future? It is obvious that the whole contention is erroneous. But let us be just; the industries themselves have never, so far as I know, put forward such an absurd proposition. Not very long this question was discussed at a special meeting called for the purpose by the London Chamber of Commerce, when the following resolution was passed, no opposition being made by the jam makers:—"That in the opinion of this meeting foreign State bounties which 'protect' foreign grown and foreign refined sugar in British markets to the prejudice of British home and colonial industries, are a violation of the true principles of Free Trade, and that their abolition is called for in the true interests of British commerce."

There was at this meeting a good attendance of representatives of the jam industry. One of them stated distinctly that a rise of £1 or £2 in the price of sugar would make no difference to their trade, and no one disputed this assertion. This ought to be conclusive, but before leaving this point I should like to read to you a letter which I received in May, 1889, on the subject from Messrs. Keiller & Sons, the well-known jam and marmalade makers.

"As large consumers of sugar, we trust the efforts of your Association will succeed in spreading the knowledge of facts bearing on the question of sugar bounties. The more widely these are known and the better understood, the more evident will it appear that the abolition of bounties would not injure the fruit growing, fruit preserving, and confectionery trades of this country, but will confer a direct benefit on them by giving them an ultimately cheaper as well as more regular and more reliable supply of sugar. More than a year ago we expressed this opinion to Mr. J. Duncan, and subsequent discussion and study of the question have served to confirm it. An international agreement on the sugar bounties question would be a blow to bounties of all kinds, which might

be applied to any trade, and those who are fortunate enough to bring negotiations on the subject to a successful issue will merit the gratitude of the working-classes as well as the manufacturers and merchants of the country."

I wish now to say a word as to the supposed gain to this country in consequence of these bounties. I hold that it can be conclusively proved that, not only are we not gaining, but that we are losing considerably by their operation. Of course, I recognise that our consumers of sugar are benefiting slightly by the bounties—I am ready to admit to the extent of £1 per ton. But there is a good deal to be set against this on the other side. Let me point out some of the ways in which we are losing. In the first place, there is our refining industry, and it is not difficult to estimate our loss here. Up to the year 1881, 84 per cent. of our total consumption of sugar was refined in this country, and, but for the bounties, there is no reason why 84 per cent. of our present consumption should not still be refined here. In this case our refiners would now be turning out 1,200,000 tons of refined sugar annually, instead of 600,000 tons as they are actually doing. The cost of refining is, roughly, £2 per ton, so that here is a loss to the country of £1,200,000 to set against our gain of £1 per ton on 1,500,000 tons of sugar, or £1,500,000.

The second large item of loss to which I may call your attention is that to our engineering industry, and it arises in this way. None of the machinery used in the production of beet sugar is made in this country, nor are any of the breakages or yearly repairs of beet-sugar machinery made good by our engineers. All the beet-growing countries are fenced round with such a wall of protection that this is impossible. But, in the case of cane sugar, our engineers not only make almost the whole of the machinery used in our colonies, but largely also that used in foreign cane-sugar producing countries—Brazil, Cuba, Porto Rico, Hawaii, &c. It is naturally impossible to put a precise figure upon the loss which thus arises through the supplanting of cane sugar by beet—it may be anything from £500,000 to £1,000,000, but it may safely be said that £500,000 per annum is within the mark.

Then there is a loss to our shipowners, dock and warehouse keepers, which can hardly be less than another £250,000.

Again, there are the losses to our manure makers, bag makers, cotton spinners, leather

makers, manufacturers of supplies of all kinds, amounting in all to a large sum.

Thus we have on the one hand a gain to our consumer of £1,500,000, and a loss to our refiners, manufacturers, ship owners, &c., of £1,950,000, without taking into account the last item to which I have alluded.

Also we must not forget that these bounties act as a tax upon the West Indies and Mauritius of about £400,000.

Again, there is not a doubt that, but for these bounties, a large sugar-growing industry would exist in this country, which would be a great alleviation to our agricultural industry. This is not a speculative conjecture. Experiments have been carried out on a conclusive scale by Professor Schack Sommer and others, which have proved beyond the possibility of doubt that sugar-beet can be grown of fully equal quality and quantity per acre as that grown in the best parts of Germany. What the loss is on this account it is difficult to say precisely, but if we produced even 50,000 tons of beet sugar this would represent a loss of another £500,000.

I think I have shown you that these bounties are no gain to the country as a whole, and that if our consumers are benefiting by them to the extent of £1,500,000, other British interests are losing by them to a far larger extent.

Having now dealt with the sugar bounty question as it affects this country and our West Indian Colonies, let us very shortly consider the question from the continental point of view. That these bounties are a heavy strain upon the finances of the countries which give them is obvious. And the amount contributed by the foreign Governments in the way of bounties by no means represents the whole cost to the foreign taxpayer. Take the case of Germany for instance. The German Government pays a bounty of 25s. per ton on every ton of sugar exported from Germany. No bounty is given by the Government on sugar consumed at home; but it is obvious that the man in Germany who has sugar to sell will not sell at home if he can get a better price abroad, so that he does not sell his sugar for home consumption unless the home consumer is prepared to pay him a similar bounty to that granted by the Government on exportation.

In France alone, M. Leroy Beaulieu estimates the bounty given at 112,000,000 frs., equal to about £4,500,000 sterling. You will readily believe, therefore, that the bounty system is very costly and very burdensome. Still, this

does not seem to have produced any discontent, nor has there ever been any marked indication that this consideration was likely to bring about a cessation of the system. It is true that for the last few years there have been decided indications that Germany was anxious to get the whole system put an end to; also that in 1888 all the European Governments granting bounties, except France, agreed to abandon bounties under certain conditions. But quite recently a new factor has arisen: the United States have imposed countervailing duties. All sugars now receiving a bounty have to pay a duty equal to the bounty, in addition to the ordinary duty, on entering the United States. This has been a great blow to the system. Foreign Governments do not mind giving bounties with the object of stimulating an industry, but it is very galling when a bounty is given for this purpose to find it popped into the exchequer of another nation for the relief of the taxpayers of that country. Hence, the foreign Powers generally are far more ready to consider the question of the abolition of bounties than they have ever been before. As regards Belgium, Holland, Germany, and Austria, there is but little doubt that they are quite willing to abandon their bounties provided these are abandoned all round. France is the only difficulty in the way, and the position of France is peculiar. The cost of production of sugar in France is higher than it is in either Belgium, Germany, or Austria, and hence the sugar-producers in France contend that it is only just that they should receive a higher bounty than the sugar-producers of other countries. This is a strange doctrine to our ears, but economics, as you know, are viewed from a very different standpoint on the continent to that from which they are viewed on this side of the Channel. As a matter of fact, the French producers do enjoy a far higher bounty than any of their European competitors, and this higher bounty enables them to compete with Germany in British markets. The bounty in France is about £4 10s. per ton, and in Germany £1 5s. per ton. It is obvious, therefore, that if all bounties are done away with, France will find herself crippled in her competition. Hence, France so far is only willing to join in a convention under which she shall be allowed to continue to grant a bounty of £1 10s. or £2 per ton, whilst all the other Powers shall be bound to abolish their bounty in toto. You no doubt understand that there is no question of any competition in any of the European

markets. These are all rigidly protected. The struggle between the European bounty-giving countries is who is to receive the largest artificial advantage in the British markets; in other words, who shall receive the largest amount of protection in the British market. It might have been thought that when it became a question of protection in British markets, the Cobden Club and our Free Trade friends might have had a word to say, and so they have, and a very curious word it is. We must not listen to any idea of protection to a British industry in British markets, they say, but we have no objection to protection if it is a foreign industry which is protected by Foreign Government, and it is part of our settled Free Trade policy to connive at this protection. Is not this reducing all Free Trade principles to a mockery?

But there is a party in France, and a strong party, which takes a longer-sighted view of the question than the sugar-growers. They say bounties are unsound, and, in so far as they tend to create an industry which depends upon a foreign market—a market in which the industry could not compete without the bounty, they consider that it is building a house upon sand which must sooner or later collapse. They point out that the huge internal duty which is necessitated by these bounties is stifling home consumption, and that the really sound course would be to abolish the bounties and to largely reduce the internal duty, and that this policy would so stimulate the home consumption as to render the industry very soon altogether independent of foreign markets. M. Leroy Beaulieu is the able exponent of this view, and my belief is that it will be found to be the view of the majority in France. It is further urged that if Her Majesty's Government would announce its intention of proposing countervailing duties in the event of the Conference which is about to take place not coming to a satisfactory convention for the abolition of bounties, such an announcement would certainly ensure a satisfactory result. In fact, such an announcement on the part of the Government would at once bring about a solution of the question. Practically every other means have been tried, and have failed. Unless and until our Government is prepared to take up a firm attitude I fear that negotiation will lead to no result.

I have now described to you very shortly the effects which these bounties have had upon our colonies, upon the mother country, and upon the Continent, and whichever way we

look at them they appear to be mischievous in the highest degree. On the Continent the advantages to the industry receiving them are materially less than the cost to the taxpayer granting them; in this country the gain to the consumers of £1,500,000 is dearly purchased by the loss of some £2,000,000 to £3,000,000 to the large industries of this country. Finally, in those of our colonies affected by them they threaten widespread ruin. Surely Lord Farrer did not use too strong a word when he called bounties an abomination. What is so strange is Lord Farrer's insistence of our toleration of this abomination.

Allow me, in conclusion, to quote a paragraph from an article in the *Chamber of Commerce Journal* dealing with bounties. It says:—

“Bounties involve a direct breach of every canon of free trade; but they are something even worse than this, for they carry the war right into the enemy's camp. The bounty, like a live shell, is not intended for effect except in the enemy's quarters. It is an act of war. It places, and is intended to place, a foreign commodity in a neutral market at a lower price than the native or the ‘natural’ commodity. The effect would be the same if the bounty-giving Power should compel the authorities of the market to place a tax on all similar commodities, but leave their own to enter free.”

The result of the bounty system is a crucial instance of the mischief arising from our departure from the true principles of Free Trade. It is idle to pretend that we are free from blame or responsibility in the matter. We have deliberately tolerated this rampant system of protection in our own markets under the erroneous belief that we were benefiting by doing so. Apart from the claims of justice, we have departed from the doctrines of Cobden and of all the leading economists under whose teaching we adopted Free Trade some 50 years ago. A new Cobden is now wanted to lead us back to the only sound principle—that principle which Ricardo taught us as the only true one, viz., that “Perfect equality, perfect justice, and perfect security are the only as they are the infallible means of securing the greatest amount of prosperity to all.”

DISCUSSION.

The CHAIRMAN, in moving a vote of thanks to Mr. Neville Lubbock, said the greatest advocate of bounties would admit that the paper had been a fair and just presentation of the case against them. He

ventured to say there was no one in that room who had heard it who should not willingly join in the denunciation of bounties. Those in this country who were devout believers in free trade necessarily believed that free trade was as much attacked by artificial stimulants of industry as it was by artificial impediments. No definition of free trade could be correct which did not realise that it consisted in the natural flow of commerce, unaided and unimpeded in its proper channel. They had to thank Mr. Lubbock for a very interesting history of those colonies to which he had particularly referred. He was sorry to add, as Mr. Chamberlain said yesterday in the House of Commons, that it was not creditable to history. If they took the case of Dominique, of which they had been in possession for over 100 years, they could not say that they had done anything to promote the prosperity of the island, or the great well-being of its inhabitants. That was a great reflection upon this country, and he was glad that Mr. Chamberlain had realised the duty, not only of national development, but had widened the scope of the application of that doctrine by teaching the duty of Imperial development. Their position in the case of Dominique was as bad as any class of absentee landlords who drew means from property, and never realised its duties, who exercised its rights, but thought it had no obligations. These persons committed a great economic mistake. These doctrines might be applied to nations as well as to individuals. When proposals were made to develop our great colonial estates, as well as to expand the Empire generally, and when the development took the form, as was proposed, of making roads, it seemed they were fulfilling an obligation of the very highest character. Everyone knew what the advantage of good roads had been in their own country, and how much they were valued by the localities in Ireland. In the case of Scotland, he might be permitted to quote the couplet—

“Had you but seen these roads before they were made,
You'd have held up your hands and blessed General Wade.”

They had to face the problem, what should be done to remedy this, because some remedy was obviously required. He would not follow Mr. Lubbock into the difficult and perhaps arguable question of the imposition of countervailing duties. No one could rightfully avail himself of the profits derived from bounties, except from the most selfish standpoint. He was not aware that it was proposed as a practicable measure to enact those duties, and if it were it would lead to a careful discussion of the whole subject, and of the economical basis of it in the House of Commons. But certain things were proposed with which one must thoroughly agree; for instance, grants in aid—whether they were to be called mere doles or not, was unimportant—were urgently called for to meet certain deficits in some of the islands. These grants had been given to various branches of the United King-

dom. Last session, or the session before, Parliament made a distinct grant in aid of a railway on the west coast of Scotland, and if that could be done for parts of the United Kingdom, it seemed that a similar claim might be set up for other parts of the Empire which formed the poorer parts in the Imperial frame. In any such proposal he thought the House of Commons would probably readily concur. The only doubt he had in his mind was whether they would be as great a benefit as if they took the form of loans. To make loans to islands, many of which had actual deficits, might be regarded in some measure as not only unwise, but almost an irony. On the other hand, grants given in aid merely had not only the disadvantages of want of economy in administration, but they were liable to produce lethargy on the part of those who received them. Loans for the development of public works carried with them the stimulus to public exertion in order that repayment might be met. Those were all forms in which relief could be given. Having carefully read the report of the Commission, he was sorry to hear so distinct a condemnation of encouraging varying forms of industry. He should be the last to supplant sugar planting; but, on the other hand, he had often observed towns and communities which were very apt to suffer from the existence of one staple form of trade. If that trade was overtaken by calamity or by the advance of science—and it was within the bounds of possibility that the artificial production of sugar from its component elements was not beyond the reach of science ultimately—disaster was the result. Under favourable circumstances, and without anything in the shape of artificial stimulation, if you could combine other industries in the islands, it would be a benefit, and would go to remedy the great disadvantages under which the islands lie. But they had to deal with the facts of to-day, and on that point it was conclusive that they must deal with the sugar industry. Therefore, in obedience to not only sympathy, but also to economic principles, and dealing with the subject economically, it seemed to him that the proposals of the Colonial Secretary to make grants in aid of the condition of many of these islands was to be entirely approved, and that they had no alternative but to support that ministerial course of action. While he had ventured to express doubts on certain points, he was sure they were all indebted to Mr. Lubbock for bringing before them in a condensed and in a very striking manner the facts of the situation, and no one could have listened to the paper without realising the cogency of his argument, and the strength of the points which he had so ably put forward. He (the Chairman) confessed that on certain of them his former doubts had been removed, and he hoped everyone would be moved both by sympathy and judgment to give the best consideration to the condition of these old colonies, and to do all they possibly could on economic and proper grounds to relieve the position in which they were most unfortunately placed.

Mr. EDWARD PACKARD said he was sure every member of that Society and the public at large would equally join in thanking Mr. Lubbock for the way in which he had dealt with this matter. What the English public wanted was to have the facts of such an intricate case placed clearly before them. The British instinct of fair play was so imbued in the public mind that there was no fear that when Englishmen saw the injustice which was being done to this great industry, they would support any Government that took measures to place it in the position it ought to occupy, viz., a position of free trade. Speaking from a somewhat lengthy knowledge of the West Indian Islands, he might say that all they asked for was the same facility to carry on business that other nations possessed. They did not ask for any privilege or bounty; they merely asked not to be placed at a disadvantage. If they were placed in a position to compete fairly with other nations, they could compete successfully with them. If bounties were removed, they were quite as capable of producing beet sugar in this country as Belgium. The agriculturists of England were prevented by this iniquitous system which was imposed upon them by foreign countries from carrying on a national industry in the cultivation of beet, which, from experiments, had been successfully shown to be capable of being carried on. It had been said by some who did not understand the question that the people in the West Indies were behind the times, that their machinery was antiquated, and that scientific methods were not adopted as on the continent; but this was entirely untrue. In Mauritius and Queensland, they had some of the finest machinery possible, and the best scientific aids which could exist in any part of the world, in addition to which they were capable of producing sugar at the lowest possible cost. It was said:—"Why do you carry on the antiquated system which exists in Jamaica and Barbadoes?" He thought they should not look contemptuously at the old methods, as they had advantages which were perhaps not recognised. In Jamaica they had a speciality for a particular kind of rum, which could not be produced if modern methods were adopted for making sugar. He thought they were all thankful to Mr. Lubbock for pleading on behalf of the colonies that there should be a thorough discussion throughout the whole country, and in Parliament, upon this great and important question. If the question went clearly before the British public, and was thoroughly discussed, the great injustice from which the sugar industry was suffering would be removed. It could not be to the interest of the different islands to receive a mere dole from England.

Miss WEBSTER said the great difficulty which many persons experienced was that of obtaining cane sugar, and she suggested that some measure should be introduced into Parliament whereby it might be made a

penal offence to sell any sugar as cane sugar which was not. Beet sugar had nothing like the sweetening properties that cane had, nor had it the property of keeping preserves. She thought it would be an advantage to the colonies if they could sell their product as cane sugar, and those who wished to purchase it as such could do so, even if the price were somewhat higher than beet.

The CHAIRMAN said he was not sure that a sale of beet sugar as cane would not come within the Food and Drugs Act, but it certainly would be a civil wrong for which redress could be obtained at law.

The resolution having passed unanimously,

Mr. NEVILLE LUBBOCK said he might perhaps be permitted to remove one misapprehension from the mind of the Chairman with regard to the minor industries. What he read was a quotation from the Commissioner's Report. He did not express any opinion of his own. Alternative industries had never been lost sight of. He did not suppose anyone had done so much to start other industries as the sugar people had done, and in some instances they had succeeded, but, unfortunately, in others they had failed. He remembered on one occasion hearing a paper read at the Colonial Institute, in which some elaborate calculations were made to show that anyone laying out capital upon the cultivation of quinine in Jamaica would in the course of a few years reap a larger income, but this calculation was based on quinine being 3s. an ounce. Unfortunately, some gentlemen did invest their money upon this recommendation, but by the time the quinine reached London the price had fallen to 1s. The same remark was applicable in the case of arrowroot, which was grown in St. Vincent. In the case of a large staple like sugar, there would always be a large demand for it. In going into minor industries one ran the risk of reducing the price by swamping the market. There was a good deal in the suggestion which had been made by Miss Webster. Some four or five years ago, in giving evidence before a Committee of the House of Commons, he suggested that every grocer should be forced to sell sugar as cane, beet, or mixed, but the committee did not make the recommendation. As a rule committees had rather an objection to interfering with shopkeepers. At the present time there was a large sale of beet sugar, which was coloured with aniline dye that was sold as Demerara. Demerara sugar having a great reputation, some refiners thought there was a splendid opportunity to imitate it, and accordingly they got white beet and coloured it; but it had been found very difficult to get a conviction. Several shopkeepers had been brought up under the Food and Drugs Act, and some convictions had resulted, but owing to the curious language of the Act which provided that it must be shown that the article was "not of the nature and substance demanded,"

magistrates as often as not refused to commit. If it could be made compulsory to sell cane sugar as such and beet as beet, the cane sugar industry would be materially benefited.

SIXTEENTH ORDINARY MEETING.

Wednesday, March 30, 1898; J. W. SWAN, F.R.S., in the chair.

The following candidates were proposed for election as members of the Society:—

Arthur, Allan, 7/1, Lyons-range, Calcutta, India.

Hodgkin, Thomas, Bank, Newcastle-on-Tyne.

James, John Herbert, 3, King's-bench-walk, Temple, E.C.

Lyon, Brigade-Surgeon-Lieut.-Col., Isidore B., C.I.E., 164, Sutherland-avenue, W.

Stevens, H. W., 3, Hastings-street, Calcutta, India.

Storrar, David, Kirkcaldy, Fife, N.B.

The following candidates were balloted for and duly elected Members of the Society:—

Alward, George Lowe, 11, Hainton-street, Grimsby.

Barrington-Baker, Lieut.-Colonel Robert, Royal Naval Ordnance Depot, Plymouth.

Bowman, Rev. Arthur H., 48, Foxgrove-road, Beckenham, Kent.

Edmonds, Frederic Bernard, 6, Clement's-inn, W.C.

Grice, Walter T., 9, Dalhousie-square, Calcutta, India.

The paper read was—

TELEGRAPHY ACROSS SPACE.

BY SILVANUS P. THOMPSON, F.R.S.

There is no such thing as wireless telegraphy. True, one can send signals for a distance of a yard or two without any wires, but in all the recent successful attempts to telegraph across space, whether by electric waves or by other means, wires are used. They do not, indeed, run from the sending station to the receiving station, but are used as base-lines. For example, in the case of the longest distance yet reached in telegraphing by electric waves—thirteen miles over open country—the maximum distance attained in the recent experiments of Professor Slaby, the length of the wires used as base-lines at each end was nearly 1,000 feet. As will be seen, in every case, wires or their equivalent are used to serve either as base-lines or as base-areas in the transmission.

Setting aside the mediæval myth of a sympathetic magnetic telegraph with two mere compass-needles to point to letters ranged around a dial, there are three generic methods

by which it has been found possible to signal across space without any directly communicating wire or cable. These may be conveniently classified as follows:—

1. Conduction methods.
2. Induction methods.
3. Wave methods.

I.—CONDUCTION METHODS.

These methods depend upon the use of water or earth as a means of conducting a fraction of the electric current from the base-line at the sending end to the base-line at the receiving end.

From the earliest days of telegraphy it has been a familiar fact that either earth or water might serve as a return circuit for an electric current; and, under certain circumstances, that signals could be sent even with an absolute gap in the metallic line, if there were provided, by means of earth or water, a sufficiently good path to enable current in adequate amount to be received beyond the gap in the line. This method has sometimes been called the leakage method, since it depends upon the circumstance that electric currents flowing in a conducting medium such as water, or moist earth, do not flow exclusively or even mainly along the path of least resistance, but spread out, some flowing along paths of greater resistance. If current enters a conducting stratum at any point by a single electrode, A, and leaves it at some other point by another suitable electrode, B, some of the current will certainly flow straight from A to B; yet the greater part will not so flow, but will stream around from A to B in long, curving paths. If then two other electrodes, C and D, are inserted in one of these stream-paths at a distance from A and B, some of the current—perhaps only a small percentage of it—may be picked up by a metallic line joining C to D. Hence it is possible, using AB as a sending base-line, to signal to CD as a receiving base-line at a distant place. The only limits to this method of telegraphy across space are (1) the strength of the original currents used in the sending base-line AB; (2) the sensitiveness of the apparatus used in the receiving base-line CD; (3) the ratio between the space-distance from AB to CD and the lengths of the two base-lines. This system of telegraphing across space has been proposed at various times. It has been used by Mr. Preece in several of those many experiments which he has made from time to time, and which will entitle him to be regarded as one of the foremost pioneers in this entire branch of telegraphic enterprise.

Morse himself—as recorded in Vail's early work on Telegraphy—worked at this subject, and made experiments in 1842 on the Susquehanna river, about a mile wide. He engaged Professor Gale to investigate the best conditions, and came to the conclusion that the base-lines should be three times as long as the distance to be crossed. Mr. Dering, an English telegraph engineer, and Mr. Lindsay, of Dundee, have also worked in this direction.

After the introduction in 1877-78 of the Bell telephone it was found that the extraordinary sensitiveness of that instrument furnished a new means of picking up currents that would otherwise be too feeble to produce intelligible signals. The importance of this circumstance in extending the possibilities of distance-telegraphy was not lost upon Mr. Preece. In 1882 he conducted a series of researches upon the establishment of telegraphic communication between the Isle of Wight and the Hampshire coast without any connecting cable across the Solent. An account of these experiments will be found in the report of the British Association for that year. Large metal plates to serve as electrodes were immersed in the sea at the ends of the two base-lines. On the Hampshire coast the base-line extended from Portsmouth through Southampton to Hurst Castle, a length of 20 miles. On the island the base-line extended from Ryde through Newport to Sconce Point, and was about 16 miles long. From Portsmouth to Ryde the breadth of the sea is 6 miles, while Hurst Castle is only about a mile from Sconce Point. Hence in this case the length of the base-lines considerably exceeded the average distance to be crossed. With this arrangement signals were passed in dot and dash which could be read on the Morse system with ease; but telephonic speech was not feasible. After many other experiments to be mentioned under the next heading, Mr. Preece established communication in the winter of 1893-4 across the Kilbrannen Sound between the Isle of Arran and Kintyre, a distance of over 4 miles. He also maintained telephonic speech across Loch Ness, a distance of $1\frac{1}{4}$ miles.

In the experiments from Arran to Kintyre, parallel wires about 3 miles long were used as base-lines along the coast, while in some of the experiments two other base-lines were used, being insulated wires laid along each coast at a height of about 500 feet above sea level. A detailed account of these experiments will be found in the report of the British

Association for 1894, and is also given in *The Electrician*, vol. 33, August 17, 1894.

A year earlier Mr. Preece had made some striking experiments in the Bristol Channel between Lavernock Point on the South Wales coast and the islands of the Flat Holm and the Steep Holm, the distances of which are respectively 3.1 and 5.35 miles. His base-line on the shore at Lavernock Point was a pair of copper wires weighing 400 lbs. per mile, suspended on poles for a length of 1,267 yards, their circuit being completed through earth. An alternating current was sent into this base-line by an alternator worked by a 2 horse-power steam-engine, the voltage being 150 volts, the frequency 192 periods per second, and the current (maximum) 15 amperes. These alternations were broken up into dots and dashes by use of a Morse key. The signals were read on a pair of receiving telephones inserted in the distant base-line, which in each case ran across the island and dipped into the sea. The length of these is not stated. Mr. Preece received messages easily over the three miles separating the mainland from the Flat Holm. But at the Steep Holm, 5.35 miles away, though the signals were feebly perceptible, telegraphic conversation was impracticable, as the sound could not be differentiated into dots and dashes. Mr. Preece came to the conclusion that with two base-lines, each ten miles long, he could with ease signal across a distance of ten miles.

Professor Trowbridge, of Harvard, has also investigated the possibility of transmitting signals through the earth by conduction, using a rapidly interrupted primary current, and a telephonic receiving apparatus.

Many experiments have been made under accidental circumstances, all tending to prove the possibility of this mode of transmitting signals through the earth itself. The instruments in Greenwich Observatory are affected by the stray currents that escape into the earth from the badly insulated return circuit of the City and South London Electric Railway, $4\frac{1}{2}$ miles away. Another example is afforded by an accident which occurred some 10 years since at the Ferranti electric lighting station at Deptford, when one night one of the dynamos by some derangement became connected to earth. The whole of the railway telegraphs in the signal-boxes of the railways in South London were temporarily put out of order and rendered inoperative, while the currents flowing in the earth were perceived in the telegraph instru-

ments so far northwards as Leicester, and so far south as in Paris. If this could occur as a mere accident, it is obvious that, with properly thought-out arrangements, signals could easily be sent from one part of the globe to another by conduction through earth or water.

Most striking of all the cases of distance-signalling by conductive methods is that presented by the transmission of signals over nearly three miles, which was carried out in 1894 by Dr. W. Rathenau, Mr. E. Rathenau, and Professor Rubens. They selected as a suitable place for operations the open water of the Wannsee, which opens into the Havel, near Potsdam. Here at the south end, near the Friedrich-Wilhelmsbrücke they immersed two metal electrodes, each having about fifteen square metres of surface, at the two ends of a base-line about 550 feet long. With 75 accumulators and a rotating interruptor giving about 150 currents per second, and a Morse key, they injected signals into the base-line. At a distance of $4\frac{1}{2}$ kilometres, or nearly three miles across the water, near the shore at Neu Cladow, they set up the secondary base-line, having electrodes of about four square metres each. These were hung in the water from two boats between which the connecting line—about 330 feet long—was stretched. In this line was inserted a telephone receiver of usual pattern. The current used was about three amperes, and there was not the slightest difficulty in hearing the dot-and-dash messages. Several situations for the receiving base-line were tried: and it appeared that the interposition of a large sandbank between the two stations made very little difference.

II.—INDUCTION METHODS.

Induction methods are of two varieties. An electric charge upon a conductor may induce another electric charge upon another conductor at a distance by influence, or electrostatic induction. An electric current in a wire, during such time as it is increasing or diminishing, may induce another electric current in another wire in its neighbourhood by electromagnetic induction.

So far as I am aware, the only case in which electrostatic induction has been used in electric signalling, is that of telegraphing (or telephoning) to trains in motion, as suggested about thirteen years ago by Mr. Wiley Smith, of Kansas City. If a wire suspended over a train is electrified, either positively or negatively, charges are induced upon the metallic roofs of the cars, and if these are

suitably connected to instruments on board the train, signals may be exchanged between train and wire without any metallic connection between the two. This suggestion was further developed, about the year 1886, by Mr. Phelps, and by Messrs. Gilliland and Edison. Descriptions of their methods will be found in the American electrical journals of that date. The system was successful both for telegraphing and telephoning, and was, indeed, adopted for a time by the Lehigh Valley Railroad Company. But it has been abandoned for a very simple reason. One of the consolations of railway travelling, is that one is free from being disturbed by telegraph or telephone. No one on board an express wants to telegraph or be telegraphed to.

Electromagnetic induction has played so important a part in distance telegraphy that it must receive a more extended notice. Very early after the introduction of the commercial telephone, troubles arose from the exceeding sensitiveness of the instrument. Conversations in one line were overheard in another; while the ear was disturbed by an incessant buzz, or rattle, from the interference of stray currents from neighbouring telegraph lines. All these were at first attributed to induction; that is to say, to the electromagnetic influence of the currents in one line upon the neighbouring line. No doubt, in some cases, this is a cause; but unquestionably, in many of the cases, the disturbance was due not to induction at all, but either to leakage of currents across the surfaces of the insulating supports, over films of dirt or moisture, or else to leakage of currents from one line into the other through the earth-plates or earth connections. Unless circuits with metallic returns are used, it is certain that the earth-return will afford a means for stray currents to find their way into the telephone lines. Mr. Preece has narrated many cases in which telegraph or telephone messages that are being transmitted along some line have been heard—or rather overheard—in telephonic instruments in some totally disconnected and distant line. Many of these are due doubtless to stray currents through earth; but some are unquestionably due to true induction. A line or circuit absolutely insulated from any earth contact or earth-return may yet act inductively. During the brief instant while the current in it is growing, that current is setting up a magnetic field in the surrounding region, extending indefinitely, but feebly, into space. As the current dies away again, this magnetic

field also dies away. If in its growth or decrease this magnetic field encounters other wires, it sets up electromotive forces in them, and thus originates disturbances. For the propagation of this effect from wire to wire no contact is needed. It is an effect that is dependent upon the properties of the intervening medium, and is proportional to its magnetic permeability. The ether of space itself, air, water, soil, and rock, all are of about equal permeability. Hence this kind of induction may be propagated from circuit to circuit, whatever natural material intervenes. Mr. Preece has made repeated researches with the view of utilising this effect for the purpose of distance-telegraphy. He has erected parallel base-lines, sometimes in South Wales, sometimes near the mouth of the Dee, sometimes in Scotland. He has laid out, flat on the ground, great squares of insulated wire, to test the inductive transmission from one area to another. On Newcastle town moor, and on the sands at Penarth, he has thus operated. It is not always easy in his experiments, particularly in those where earth-connections were used, to be certain how much of the effect was due to true induction, and how much to earth-conduction. But in some of the cases there can be no doubt whatever. An excellent *résumé* of his work was given by him at the Chicago Congress in 1893. In this he describes how in one series of experiments he laid out on a level plain two $\frac{1}{4}$ -mile squares of copper wire insulated with gutta-percha, the distances between the two nearest sides of the two squares being also a quarter of a mile. In this case, using rapidly-interrupted or vibratory currents, and a Morse key to break them up into Morse signals, and applying in the other circuit a receiving telephone, conversation in the Morse code could be held readily between the two operators. This arrangement precluded all idea of earth-conduction. In effect, Mr. Preece was working with a strange species of transformer, of which his two squares constituted respectively the "primary" and the "secondary," the "core" of the transformer being in this case partly of earth and partly of air. Mr. A. W. Heaviside has described an analogous case in which, wishing to establish telephonic communication to the bottom of a colliery in the north of England, he arranged a circuit in a triangular form along galleries about $2\frac{1}{4}$ miles in total length, at a depth of 60 fathoms. On the surface of the colliery another circuit was laid out in triangular lines of equal size, over and parallel to the underground line. Here,

again, telephonic speech was perfectly clear by induction from line to line—or rather, in this case, from area to area. Each area enclosed something like 700,000 square yards, an ample base-area when the distance to be penetrated was but 120 yards.

Earlier than the date of either of these experiments, the late Mr. Willoughby Smith had shown how, using two coiled circuits of wire at a distance of some yards apart, telephonic messages could be sent across air, or even through walls and floors.

The greatest distance to which Mr. Preece's experiments upon telegraph lines have been carried is 40 miles, namely, between the telegraph lines that run across the Scottish border by the east and west coasts respectively. Sounds produced in the Newcastle and Jedburgh line were distinctly heard on the parallel line at Greta, though there was no line connecting the two places. Here, however, since both lines used earth-returns, it is probable that most of the effect was due to conduction, not to true induction.

Instruments which operate by means of alternating currents of high frequency, like Mr. Langdon-Davies's phonophore, are peculiarly liable to set up disturbance in other circuits. A single phonophore circuit can be heard in lines a hundred miles away. When this first came to my notice it impressed me greatly, and, coupled in my mind with the Ferranti incident mentioned above, caused me to offer to one of my financial friends in the City, some eight years ago, to undertake seriously to establish telegraphic communication with the Cape, provided £10,000 were forthcoming to establish the necessary basal circuits in the two countries, and the instruments for creating the currents. My offer was deemed too visionary for acceptance. The thing, however, is quite feasible. The one necessary thing is the adequate base-lines or areas. All the rest is detail.

One must not close this section without reverting to a most pregnant point of advance made about 1888 or 1889 by Dr. Oliver Lodge. When experimenting upon the oscillatory discharge, he conceived the happy idea of turning two circuits into resonance, or as he termed it, "syntony" with one another, in such a way that when an oscillating electric spark occurred in one of the circuits, the inductive effect on the other immediately set up in it electric oscillations which manifested themselves by an overflow-spark. I call this experiment pregnant because it affords a hint

of another possibility, namely, that of signalling inductively from one area to another, and using around those areas, not merely circuits of wires, but syntonic circuits, which, therefore, are necessarily much more sensitive in their response one to the other. Some of Tesla's high-frequency experiments also have an obvious bearing on this point.

III.—ELECTRIC WAVE METHODS.

After Clerk-Maxwell had predicted the existence of electromagnetic waves, and had shown that their speed of propagation is identical with that of light, it required, in reality, very little to demonstrate by experiment the existence of such waves. But that *very little* was not actually achieved until the year 1888, when the lamented Professor Heinrich Hertz showed simple methods of producing, detecting, and measuring these waves. It had been known for many years, from the predictions of Kelvin and Von Helmholtz, and confirmed by the experiments of Feddersen, that in many cases an electric discharge is of an oscillatory character. In the years 1887-8 Lodge, Fitzgerald, and others were investigating the nature of these oscillations, and the manner in which they are guided by conducting wires, when Hertz conceived the idea of investigating the disturbances which such oscillatory discharges set up in the surrounding space. He showed that, given a simple apparatus, which he called an "oscillator," consisting of two metal plates or conductors, connected by a conductor interrupted at one intermediate point by a "spark-gap," the oscillator on the appearance of each spark emitted a train of electric waves into the surrounding space. He further showed that if a mere circuit or ring of wire of suitable size, the continuity of which is interrupted at one point by a minute gap, is placed in the path of these travelling waves in a suitable position, the waves as they reach it set up electric surges in this wire; and, if sufficiently energetic, cause it to show a small spark in the gap. This simple detecting device he termed a "resonator." Armed with these apparently primitive pieces of apparatus he then devoted himself to the task of exploring the propagation of the waves. He found that, like waves of light they could be reflected, by metallic surfaces, could be refracted by prisms, concentrated by lenses, and even could be polarised. He measured their wave-length and velocity of propagation. He found that they could pass readily through walls of

wood, stone, or brick, which are opaque to ordinary light-waves. Metals and other conductors of electricity, on the contrary, absorbed them, and were consequently opaque.

In these researches of Hertz, we meet, for the first time,* with the recognition of a true travelling wave. With this immense discovery, there was opened out an entirely new field of possibilities. Hitherto, there had been inductive actions known which might reach out from wire to wire, only to fall back again when their excitant cause died away. But now the electric wave, once started on its path, did not collapse back into the wire when the spark ceased; on the contrary, it went travelling on. And just as the javelin, which can travel on after the impulse has ceased, can act at greater range than the sword, whose thrust is limited by the length of arm and blade, so the true electric wave, by the very fact that it is a true travelling wave, can carry signals to greater distances than the mere inductive influence that simply extends outwards from a wire or from a coil.

The work which Hertz had begun, was, after his death, carried on by a whole army of investigators. Of these, and of their achievements, the best account that has yet appeared is Professor Lodge's little book on "The Work of Hertz and his Successors." To that book enquirers must be recommended for details. Suffice it here to say much has been done in perfecting both the oscillator and the detector. Notable amongst these matters have been the forms of oscillator designed by Lodge and by Righi; the latter having the spark-gap immersed in oil or vaseline between two metal balls. Many forms of detector have been proposed. Very early Lodge produced one under the name of "coherer," consisting of a metallic point very lightly pressed against a metal plate, and connected in circuit with a galvanometer and a local cell. The light contact constitutes an imperfect joint, which is practically non-conductive until caused to cohere and conduct by the impact of an electric wave; or, perhaps more accurately, by the stimulus of the minute surging electric current which results from the impact of an electric wave. Subsequently, taking a hint from M. Branly, Lodge sub-

* Many years before, Professor Joseph Henry had transmitted induced electric sparks from one circuit to another in different floors of a building. Doubtless, these were oscillatory; but it is impossible, at this time, to determine whether the arrangements were such as to produce true travelling waves, or whether the action was (like Lodge's later experiment of the two syntonic circuits) merely one of electromagnetic induction.

stituted as a detector a new kind of coherer, consisting of a small glass tube partly filled with loose metallic filings—iron or nickel by preference—joined in the circuit. Such a coherer acts as a species of relay, by means of which an electric wave, incapable in itself of affecting a galvanometer or other instrument, is enabled to do so indirectly by setting into operation a local current. After the coherer has thus operated, it usually remains in the conductive state until subjected to some mechanical jar or shock. Lodge proposed to apply for this purpose a mechanical tapper worked either by clockwork or by a trembling electric mechanism. On several occasions, and notably at Oxford in 1894, he showed how such coherers could be used in transmitting telegraphic signals to a distance. He showed that they would work through solid walls. Lodge's greatest distance at that time had not exceeded some 100 or 150 yards. Communication was thus made between the University Museum and the adjacent building of the Clarendon Laboratory. For more than 18 months the Rev. F. Jarvis Smith, of Oxford, using a carbon powder coherer, has maintained communication between his house and the Millard Engineering Laboratory, over a mile away.

Even before this Mr. Nikola Tesla, in a lecture delivered at St. Louis in 1893, had made a further suggestion of great importance. He proposed to transmit electric energy by oscillations to any distance, without communicating wires, by erecting at each end of the stretch a vertical conductor joined at its lower part to the earth, and at its upper to a conducting body of large surface. This constitutes a vertical base-line from which to disseminate the oscillating disturbances.

About two years ago a young Italian, Mr. Marconi, came to this country, and succeeded in inducing the British Telegraph Department to give him facilities for experimenting upon wave-method of transmission. First upon Salisbury Plain, and then across the Bristol Channel, he succeeded in transmitting Morse signals to greater distances than any one had previously attained. He sent signals from Lavernock Point to Bream Down—about nine miles as the crow flies over the open channel. To accomplish this he used as base-lines two vertical conductors earthed at their lower ends, and carrying at the top extended surfaces. He used a Righi transmitter. As receiver he employed the special form of Lodge-Branly coherer, presently to be described. This was

connected in the manner Lodge had recommended in a local circuit, and was tapped by a mechanical tapper operated by a vibrating electric mechanism. The local circuit operated a Post-office relay connected to a Morse instrument signalling the dots and dashes. The coherer was itself included in the vertical base-line. So far all is old. The special coherer used in these experiments by Marconi has very fine metallic powder, chiefly of nickel and silver, in a small glass tube exhausted of air. He also applied shunting resistances to the relay contacts; and interposed a fine iron wire closely coiled, as an impedance in the local circuit on each side of the coherer.

In 1897, some further experiments were carried out by Professor Slaby, of Charlottenburg, on an even larger scale. He abandoned every one of the novelties introduced by Marconi, and fell back upon the methods previously known. He used a simple Lodge-Branly coherer, employed elevated conductors as base-lines, discarded the useless little iron wire impedance coils in the local circuit, and substituted for the Post-office polarised relay one made out of a Weston galvanometer. His success shows that all that is essential can be thus attained. He chose as the scene of his operations the Havel, and set up elevated conductors upon the castle of the Pfaueninsel, and on the campanile of the church at Sacrow. Thus equipped, he transmitted signals, at first about three-quarters of a mile, then three miles across the water. He found trees and masts to interfere with the signals to some degree. He then proceeded, with the aid of the military authorities, to experiment over an open stretch of country—from Rangsdorf to Schöneberg. The elevated conductors were wires raised by means of hydrogen balloons to heights of nearly 1,000 feet. Signals were obtained at a distance of 21 kilometres, or over 13 miles. Neither in Marconi's nor in Slaby's successful operations were syntonic devices employed.

The following Table summarises the results of Marconi's and Slaby's work:—

	Distance.	Base-line.	Ratio.
MARCONI:—	miles	feet	
Flat Holm (sea).....	3½	150	100
Bream Down (sea).....	9	200 (?)	250 (?)
Spezia (land and sea).....	4½	100	200
Spezia (open sea).....	11	100	500
SLABY:—			
Sacrow (water and trees)	¾	80	70
Pfaueninsel (water and buildings).....	3	200	50
Rangsdorf (land).....	13½	950	70

Commenting on these results, Slaby notes

how over open sea a much greater distance appears to be attained from a base-line of given length. Assuming Marconi's best proportion, he calculates the vertical length of base-line needed for communicating across the English Channel at Dover to be 265 feet, while from London to Paris, over land and sea, would require 4,700 feet. He even estimates base-lines of 6,600 feet as sufficient, were it not for the curvature of the globe, to serve for communication across the Atlantic.

The most recent improvements made towards perfecting this method of transmission are those of Dr. Oliver Lodge, whose labours, continued during the past few months, are still in progress. He has first reorganised the transmitter apparatus so as to make it a more persistent radiator. It emits longer trains of waves. This has been accomplished by introducing in the path of the oscillations, between the spark-gap and the wings, a few turns of stout wire to act as an impedance coil. By this means the oscillations can be accurately tuned. The receiving apparatus is also tuned; in fact, each apparatus is made to operate both as emitter and as receiver, in turn, as required. Lodge has also modified the arrangements of the coherer circuits, to render them more certain of operation, no local current being allowed to pass through the coherer until after it had been affected by the waves. He has, in fact, thoroughly redesigned the sending and receiving instruments upon a rational basis, so that they shall be both less sensitive to stray impulses, and more sensitive to properly attuned waves. The results obtained with these have not yet been made public; but, employing a siphon recorder as the receiving instrument, remarkable precision of signalling has been attained. Further developments in this direction will doubtless be awaited with much interest. Meantime, in other countries, the United States, Russia, and France, other experimenters are at work. Any account given at the present time will, therefore, be necessarily incomplete.

In passing finally from a review of that which has already been attained to that which may reasonably be contemplated as within reach of attainment in the near future, I have no wish to assume the rôle of the prophet. Still less would I desire to emulate the example of the imaginative litterateur who, whether his name be Jules Verne or H. G. Wells, stimulates the public curiosity by amazing speculations, and in doing so renders the disservice that the public so stimulated is made less

capable than before of distinguishing between that which is, and that which is not, within the bounds of reasonable possibility.

It has been shown that there are three general methods of transmitting electric signals across space. All of them require base-lines or base-areas. The first—conduction—requires moist earth or water as a medium, and is for distances under three miles the most effective of the three. The second—induction—is not dependent upon earth or water, but will equally well cross air or dry rock. The third—electric wave-propagation—requires no medium beyond that of the ether of space, and is, indeed, interfered with by interposed things such as masts or trees. Given proper base-lines or base-areas; given adequate methods of throwing electric energy into the transmitting system, and sufficiently sensitive instruments to pick up and translate the signals, it is possible in my opinion so to develop each of the three methods, that by any one of them it will be possible to establish electric communication between England and America across the intervening space. It is certainly possible, either by conduction or by induction; whether by waves I am somewhat less certain. Conduction might very seriously interfere with other electric agencies, since the waste currents in the neighbourhood of the primary base-line would be very great. It is certainly possible either by conduction or induction to establish direct communication across space with either the Cape, or India, or Australia (under the same assumptions as before) and at a far less cost than that of a connecting submarine cable. I doubt very greatly whether the wave-method can be made applicable at all to these so-distant parts of the globe. But whether by conduction, by induction, or by waves, I am firmly convinced that the immediate road to commercial success lies in two things. Firstly, we must frankly recognise that there is no such thing as telegraphing without wires—that the base-line, or the base-area surrounded by wires, is a fundamental necessity. Secondly, we must look to establishing real sympathy between the sending and the receiving parts of the apparatus to render it, as far as possible, sensitive and independent, without which conditions such systems will become too costly and too unmanageable for commercial ends.

[The paper was illustrated by numerous slides illustrating the methods and instruments used by Hertz, Lodge, Righi, Marconi, and Slaby in their

investigations, and the newest syntonic apparatus of Lodge. Experiments were also shown illustrating the transmission of electric waves and their reception and detection. A small Lodge apparatus, constructed by Mr. Miller, was also exhibited in operation.]

The CHAIRMAN said no doubt all present had come with great expectations, anticipating much pleasure in hearing of the latest developments of one of the most interesting and valuable applications of modern science to useful purposes—electric telegraphy. But whatever their expectations they must have been more than realised by the exceedingly lucid exposition by Professor Thompson of a most intricate and difficult subject; so lucid in fact had it been that probably few realised how intricate it was. He felt with Professor Thompson that perhaps in the immediate future the application of wireless telegraphy to practical purposes was not quite so wide as some might have anticipated and hoped; but at the same time there were purposes to which they might reasonably hope it might be applied, such, for example, as communication between the shore and lightships, and possibly between ship and ship. It was satisfactory to learn that means were being sought for, and had been to some extent found, of differentiating one telegraphic signal sent through space from another by tuning. That was to him a particularly interesting point, and the explanations which had been given of the methods adopted by Professor Oliver Lodge for obtaining the transmission of a particular message, and the receipt of that message by the particular person intended to receive it were specially valuable. Obviously it would be very inconvenient if messages sent through space were indifferently receivable by everyone who chose to play the part of an eavesdropper. That condition of things would somewhat resemble that described in one of Hans Christian Andersen's stories, where the fumes coming from a pipkin revealed to everyone who chose to smell them what each particular person was having for dinner. It was not very desirable that that kind of curiosity should be gratified in connection with telegraphy, and it seemed to him that the uses of telegraphy through space would be very much limited if this sort of thing could not be prevented. Professor Lodge's line of experiment, however, seemed to tend in that direction, and to show the means of confining a message to the person intended to receive it. He was sure Professor Thompson would be pleased to answer any questions on any point that had not been made clear, if there were any such, any questions which could arise having been already answered in anticipation. If no one had any such query to put, he would conclude by proposing a hearty vote of thanks to Professor Thompson for his paper.

The vote of thanks was carried unanimously, and the meeting adjourned.

MEETINGS OF THE SOCIETY.

FOREIGN AND COLONIAL SECTION.

Tuesday evening:—

APRIL 5, AT 8 P.M.—“The British Empire, its Resources, and its Future.” By JOHN LOWLES, M.P. THE MARQUIS OF LORNE, K.T., G.C.M.G., will preside.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, APRIL 4...Farmers' Club, Salisbury-square Hotel, Fleet-street, E.C., 4 p.m. Dr. Voelcker, “The Root Crop: Does it pay to grow?”

Engineers, in the Theatre of the United Service Institution, Whitehall, S.W., 7½ p.m. Dr. J. C. Thresh, “The Protection of Underground Water Supplies.”

Chemical Industry (London Section), Burlington-house, W., 8 p.m. Mr. W. J. Dibdin, “The Bacterial Treatment of Sewage containing Manufacturing Refuse.”

British Architects, 9, Conduit-street, W., 8 p.m. Mr. G. Armand, “Artistic Copyright.”

Camera Club, Charing-cross-road, W.C., 8½ p.m. Mr. Law Bros, “Archæological Rambles in Greece.”

Medical, 11, Chandos-street, W., 8½ p.m.

Victoria Institute, 8, Adelphi-terrace, W.C., 4½ p.m.

Mr. S. M. Zwemer, “Star Worshipers in the East.”

TUESDAY, APRIL 5...SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Foreign and Colonial Section.) Mr. John Lowles, “The British Empire: its Resources, and its Future.”

Central Chamber of Agriculture (at the House of the Society of Arts), 11 a.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. 1. Discussion on Mr. E. W. Stoney's Paper, “Extraordinary Floods in Southern India: their Causes, and Destructive Effects on Railway Works.” 2. Mr. A. H. Preece, “The Electricity Supply of London.”

Pathological, 20, Hanover-square, W., 8½ p.m.

Zoological, 3, Hanover-square, W., 8½ p.m. 1. Prof. Sydney J. Hickson, “The Species of Corals of the Genus *Millepora*.” 2. Mr. J. Stanley Gardiner, “The Perforate Corals collected by the Author in the South Pacific.” 3. Mr. R. Lydekker, “The Geographical Races of the Banting, *Bos sondaicus*.”

Asiatic, 22, Albemarle-street, W., 4 p.m.

WEDNESDAY, APRIL 6...Geological, Burlington-house, W., 8 p.m.

Sanitary Institute, 74A, Margaret-street, W., 8 p.m. Mr. R. E. Middleton, “The Desirability of Making Water-shed Areas and Sanitary Districts Co-terminous.”

Archæological Association, 32, Sackville-street, W., 8 p.m.

Obstetrical, 20, Hanover-square, W., 8 p.m.

THURSDAY, APRIL 7. Linnean, Burlington-house, W., 8 p.m.

1. Dr. Elliott Smith, “The Brain of the Edentata, including *Chlamydomorphus*.” 2. Mr. H. Farquhar, “Preliminary Account of some New Zealand Actinaria.”

Mathematical, 22, Albemarle-street, W., 8 p.m.

Journal of the Society of Arts.

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FRIDAY, APRIL 8, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.

FOREIGN AND COLONIAL SECTION.

Tuesday, April 5, 1898; The MARQUIS OF LORNE, K.T., G.C.M.G., in the chair.

The paper read was, "The British Empire: its Resources and its Future," by JOHN LOWLES, M.P.

The paper, with a report of the discussion, will be published in a future number of the *Journal*.

Proceedings of the Society.

APPLIED ART SECTION.

Tuesday, March 29, 1898; Sir JOHN EVANS, K.C.B., D.C.L., Treas. R.S., in the chair.

The paper read was—

ENGLISH ART IN ILLUMINATED MANUSCRIPTS.

BY SIR EDWARD MAUNDE THOMPSON, K.C.B., D.C.L.

The knowledge of the history of art that is to be gathered from a study of the illuminated manuscripts of the Middle Ages would be more generally appreciated if such manuscripts were more numerous than they are. Although they have survived in fairly large numbers, yet, in the ordinary nature of things, such portable relics, easily passing from hand to hand, must always have been liable to injury and loss, and in our own country, during the periods of the dissolution of the monasteries and of the Reformation, many priceless examples must have perished. In our own day they are to be found, in any numbers, only in the national libraries or in the possession of a very few private collectors. But, although their number has become limited, and although the examples of more than ordinary merit are comparatively

few, there is no other series of artistic productions that enables us to follow so concisely the development of drawing and painting from a comparatively early date through the different epochs of the Middle Ages. The illuminated manuscript from its very shape has had an advantage which can scarcely be overrated for preserving the paintings and ornaments with which it is adorned—an advantage which is denied to the picture that hangs upon the wall exposed to the light day by day and year after year. The colours and metals of miniatures and borders, which, when the book is closed, are effectually protected from the injurious effects of exposure to light and of impurities in the air of our gas-lighted towns, remain marvellously fresh after the lapse of hundreds of years. And, again, a single volume may be a very picture-gallery in itself, containing miniature after miniature, and border on border, which delight us with their variety of drawing and ornament and design. Indeed, no artist can have a full knowledge of the development of his art who has not studied its early efforts in the illuminations of the Middle Ages. This evening we are to trace that development, as shown in the illuminated manuscripts of our own country, and we may say at once that there is no other series in which the history of that development is more interesting. The political changes through which England passed have surely left their mark upon the artistic productions, as they did upon the character, of the people; and as we move from century to century we trace the hand of the Celt, of the Roman, of the Saxon, and of the Norman, as clearly in our manuscripts as we do in the architecture of our cathedrals and in the remains of our ancient sites.

The earliest examples of illuminated manuscripts produced in England prove the existence of two distinct schools, differing essentially from one another: the one holding sway in the north of the country, the other in the south—the one excelling in ornament, the other striving after a higher form of art and developing a remarkable power in figure-drawing. Both were imported: the northern style being Celtic in its origin; the southern, there can be little doubt, being introduced into the country by the Roman missionaries.

The introduction of the Celtic style of book-decoration, originally from Ireland, into the north of England need only be referred to here very briefly. In consequence of the conversion of Oswald, who became King of Northumber-

land in the year 625, and who had accepted Christianity during his exile in the Irish monastery of Iona, Aidan, a monk of that house, became the founder of the Northumbrian Church, and as first Bishop of the see of Lindisfarne, or Holy Isle, he chose that island on the Northumbrian coast as the seat of his diocese. There was established by the brethren who accompanied him from Iona the northern school of Lindisfarne, which became famous for the finely written and ornamented manuscripts in the Celtic style which it produced. This style was that which had developed in Ireland, and which had produced such wonderful works of art as the famous book of Kells at the close of the 7th century, and in which elaborate ornamentation of the most intricate patterns was the artist's triumphant achievement. Figure-drawing was scarcely attempted, and when it was attempted the result was, according to our ideas, singularly hideous. The mechanical excellence after which the Irish artist strove seems to have killed his perception of the beauty of the lines of free drawing; but, if he lost this power of perception, there can be no question of the high pitch of excellence to which he raised his purely ornamental designs. This style then was transferred, as we have seen, to the north of England, and was the source of the decoration which, after becoming so famous at Lindisfarne, worked southward, and left its mark upon the ornamentation of the southern school. We are not here called upon to attempt to trace the origin of the Irish style of ornamentation. Its astonishing development no doubt had its beginnings quite at the commencement of the Christian era, but its application to book-decoration appears to have been of comparatively late date, probably not earlier than the 7th century.

To illustrate the Celtic style, as practised at Lindisfarne, we turn, naturally, to that wonderful book, the Lindisfarne Gospels, or Durham Book as it is also called—that never failing source of perfect examples of the varied patterns of the school. This volume, containing the four Gospels in Latin, is stated, by early tradition which we need not dispute, to have been written by Eadfrith, bishop of Lindisfarne from 698 to 721, in honour of St. Cuthbert, who died in 687. The period of the manuscript, then, is about the year 720. The very writing of the text may be in itself regarded as a work of art, so perfect is the formation of the characters; but the glory of the volume is its ornamentation, consisting of full pages of elaborate

designs, together with a page of fanciful letters and borders introducing each Gospel, besides innumerable initial letters throughout the text. There are also four remarkable drawings representing the Evangelists, executed with very little knowledge of the human figure, and having the features and draperies treated in a curiously mosaic method, but interesting from having been copied from Greek paintings. The first page from the Gospel of Saint Luke presents an excellent grouping of a variety of the patterns which are to be found in this instructive volume: "*Quoniam quidem multi conati sunt ordinare narrationem*," the introductory words of the text, written in fanciful letters. Interlaced patterns, in sections or forming knots; birds and lacertine creatures with necks and legs in intricate conjunction; circles and spirals, so peculiarly characteristic of Celtic work; and the very effective dotted patterns which border the letters or form a background to them—all harmoniously coloured in thick pigments which give to the whole the semblance of a beautifully-finished piece of porcelain or enamel.

We leave the Lindisfarne school in the north and turn to Canterbury, the gate through which the southern style of English book-decoration found its way from the Continent, and we take up a manuscript of the beginning of the 8th century, a Psalter (Cotton MS., Vespasian A. i) which belonged to the Abbey of St. Augustine, and which no doubt was written and ornamented in that house. It is a most important relic for the history of early art in this country, for in it we find an example of figure-drawing formed on a model which we recognize as Roman, combined with ornamentation which no less certainly in part is derived from the northern style of Lindisfarne. The full-page design in which the two schools are thus brought together represents David and his musicians and scribes, enclosed within a border in which we recognize the spirals and interlacings of the Celtic style with others such as the rosettes, which are of classical origin. In the decoration, however, of this manuscript, Celtic in details as it is, we have to notice a feature which is in strong contrast with the practice of the northern school—the application of gilding, even to profusion. In Irish manuscripts the employment of gold is unknown; in the Lindisfarne Gospels it is found only in minute quantity. No doubt we are to attribute the more magnificent and costly method followed in the Canterbury volume to the influence of the

rather barbaric splendour of the illuminated manuscripts of the Continent. In this manuscript the patterns are frequently traced on a gilded background.

We have already said that the southern school developed a remarkable proficiency in figure-drawing, contrasting strongly with the practice of the northern school, which chiefly confined its efforts to ornamentation. This development is conspicuous in the Anglo-Saxon manuscripts of the 10th and 11th centuries; but it differs from the broad style of the drawing which we have just now examined from the Canterbury Psalter. It is of a lighter and more delicate touch, and particularly excels in a skilful management of the draperies. There can be no doubt that its origin is to be traced to classical models, and there is evidence to prove that it was cast in the form in which it appears in English manuscripts somewhere in the north of the Frankish Empire. The locality of Metz has even been fixed as the centre whence it arose; but, without tying ourselves so closely to a particular place, we may be content with the fact that this particular style of drawing was immediately derived by the southern English school from the neighbouring continent. The earliest example to which we turn, an example which may be called the type manuscript of this style, is the Utrecht Psalter, so named from its belonging to the university of Utrecht, though it once formed a part of our Cottonian collection. The particular value of this manuscript as a standard of comparison consists in the fact of its being an actual copy of a much older original. The character of the writing is of that type of capital letters which are known as rustic capitals, a character which passed out of ordinary use as a text hand long before the period at which the Utrecht Psalter was produced; and the reason for its employment in this instance was, there can be little doubt, the desire to keep the same arrangement of text and drawings as in the original which was being copied. The time of the execution of the Utrecht Psalter is about the year 800; the manuscript from which it was copied may have been 200 years earlier. But, though this manuscript is a copy, and in a sense a facsimile copy of the original, it must not be assumed that there is no variation from the early models in the style of the later drawings. Undoubtedly there is much variation. The same illustrations were repeated in later copies of this Psalter or of others of a similar type, in the 11th and 12th centuries; and in those we find, as one would expect, the

style of drawing of the period, although the general setting of the models is preserved. In the illustrations of the Utrecht Psalter, then, we may assume that we have the reproductions of classical models, accurate in details but modified in style by the later sentiment of the art of the period. This Psalter was executed, we believe, in north-eastern France, and at an early time it was brought to England and became the property of St. Augustine's Abbey at Canterbury. The influence which the style of its drawings, and of those of other volumes of a like character which no doubt were also imported, had upon the native art was so great that the result was an absolute adoption. In the drawings of the figures of the Utrecht Psalter we find those points which are afterwards characteristic of the drawing of the Anglo-Saxon artists of the south—the attenuation of the limbs, the humping of the shoulders, and the sketchy treatment of the draperies which was later developed into the “fluttering” style, as if they were being agitated by the wind, so conspicuous in English manuscripts.

We select, as an example of finely executed English work of the latter part of the 10th century (Harleian MS., 2904), a drawing of the Crucifixion, which shows all the best qualities as well as the faults of the school. While the general execution is so pleasing, the outlines firm, and the details of the draperies in excellent style, we have the strange contrast of the exaggerated size of the open hand and of the naked foot with the absurd tapering of the lower limbs of the Virgin, ending in the impossible small-booted feet. We have, too, the humping of the shoulders in the figure of the Virgin, which we saw in the figures of the Utrecht Psalter. But the artist was not conscious of these defects, which, in our eyes, appear so glaring; and it is noticeable that the student of these early attempts of the art of the Middle Ages insensibly unlearns, as it were, the rules of perspective, and gradually falls back into the position of the artists who produced them, forgetting the shortcomings in his admiration for the real merits of their performances. It is probable that the manuscript which contains this drawing was executed in the royal city of Winchester, which, at this period, had become the centre of English art in the southern part of the country. In this volume also we have an excellent example of the ornamentation of the illuminated manuscripts of the school in the large B of the word *Beatus* which commences the Psalms. The favourite designs

of the Anglo-Saxon artist for his decorative initials and borders mainly consisted of conventional foliage, the germ of which, we think, is to be found in the classical architectural leaf mouldings which were imitated, so much in Frankish illuminated manuscripts, and were thus brought to the notice of our native draughtsmen. Within boundaries these mouldings are kept in restraint, and vary but little from their models; but in open spaces where the artist had scope for his invention he allowed it to run free, and filled his initials and borders with a profusion of interlaced and entwined leafage, not forgetting also to make use occasionally of those knotted and interlaced patterns which he had learnt from his fellow-artists of the north.

The most elaborately ornamented Anglo-Saxon manuscript of this time now in existence is the Benedictional of St. Ethelwold, Bishop of Winchester from 963 to 984, which is in possession of the Duke of Devonshire. It has as many as thirty illuminated miniatures and thirteen other ornamental pages, and originally contained even more. It is a sumptuous example of the Winchester school, brilliantly painted and profusely gilded. Selecting one of the pages of the engraved reproductions in *Archæologia*, representing the visit of the women to the Sepulchre, we have the same character of figure-drawing as in our other examples, and an instance of florid ornamentation of the border, exhibiting the leaf moulding in the compartments of the frame work and the luxuriance of foliage, to which we have referred, in the elaborate corner pieces.

Besides the illustrated Psalter, a favourite book for artistic treatment appears to have been the "Psychomachia" of Prudentius, copies of which were imported into England from the Continent. It is from an English drawing from a manuscript of this work that we may form a very favourable opinion of the powers of the Anglo-Saxon school of the south in the first half of the 11th century. This drawing is to be found in a manuscript of the Cottonian collection (Cleopatra, c. viii.) The scene represents Humility taking flight to Heaven in the presence of the Virtues, in which the flying figure is particularly graceful, and the drawing is only marred by the exaggeration of the open hand. The disposal of the draperies is especially good, and bears witness to the dexterity which the Anglo-Saxon artist had by this time acquired in this kind of drawing, for it is to be borne in mind that this miniature is only a lightly sketched illustration.

To close our series of examples of the Anglo-Saxon school, we turn to a Psalter (Cotton MS., Tiberius C. vi.) executed about the middle of the 11th century, which has, unfortunately, suffered a good deal from the effects of fire, and we select a remarkably noble drawing of St. Michael. In the rendering of the militant saint's figure the artist has been very successful; but the character of the Old Dragon has proved too much for him, and he has produced a creature whose tame docility is a proof that animal-drawing was not the *forte* of this draughtsman.

From the few specimens of Anglo-Saxon drawing that we have had before us, we are able to distinguish the leading characteristics of the southern school. A pure and realistic style of outline drawing is developed, the strength of which lies in delicacy of touch and pleasing treatment of the draperies. On the other hand, a tendency to over-refinement and exaggeration is apparent, which, had the native school continued to develop uninfluenced by foreign styles, might certainly have degenerated into the grotesque. In our photographic reproductions, unfortunately, we are unable to give the colours of the originals. As a general rule the southern artists showed excellent taste in their selection: light tints being most in favour. The best effects were produced by tinting or slightly washing with colours. Body-colours was also employed, but, in general, too heavily.

The influence which the introduction of Norman art into England wrought upon the native school was greatly to the advantage of the latter. The grafting of the foreign style on the outline drawing of the Anglo-Saxons lent to it a strength which checked the affectation towards which it was tending; and the bold free drawing which resulted is a conspicuous feature in manuscripts ornamented in England during the next three centuries. The favour shown to this style of drawing during that period is no doubt due, in the first instance, to the success with which outline-drawing had been so long practised under the Anglo-Saxon kings. Of course in some localities and under some conditions the foreign style of illumination entirely ousted the native style; and this result is perhaps more prevalent in regard to actual decoration, as distinguished from the higher style of drawing. Still, the law always holds good that national feeling will never fail in the end to assert itself, and, if the Normans succeeded in planting their art in the country

of their new conquest, sooner or later it received the stamp of English nationality.

How far the foreign influence had affected the Winchester school of illumination some hundred years after the Conquest may be judged from a series of paintings which occur in a Psalter written in Latin and Norman-French, in parallel columns, soon after the middle of the 12th century. The manuscript (Cotton MS., Nero C. iv.) was executed in the monastery of St. Swithin at Winchester, and soon afterwards passed to the nuns of Shaftesbury Abbey in Dorsetshire. Turning to the painting which represents, in two scenes, David delivering the lamb from the lion's mouth, and Samuel anointing David, we find much to remind us of the earlier Anglo-Saxon methods. The most distinctive characteristic of the drawing lies in the treatment of the drapery, which clings to the limbs and indicates their outline very markedly. This peculiarity is evident, though in a more incipient stage, in the earlier manuscripts of the Anglo-Saxon period, and, judging from other examples, it seems to be a special development of the Winchester school. Again, in the tree which fills the background of the first subject, with its curiously close-packed top of foliage and its wide-spreading branches, we recognize a connection with the luxuriant leaf ornamentation of the Anglo-Saxons. From the same manuscript we select another of the series of paintings, representing the jaws of Hell and the torments of the damned: a composition which indicates imaginative power, and shows much force in the execution—the graceful figure of the angel, who is locking the gates, contrasting pleasingly with the tormented crowd in the abyss.

A beautiful series of drawings, in a roll in the British Museum (Harley Roll Y. 6), illustrating scenes from the life of St. Guthlac, gives us an excellent idea of the development to which outline-drawing had attained in England in the 12th century. Here again in the careful treatment of the drapery is manifest the result of the old teaching; but a greater depth is obtained by the stronger definition of the shadows in the folds. The scene of the death of the saint is, altogether, the best of the series.

It will have been observed that, in our review of the different examples which have passed under our eyes, we have been gradually falling into two lines of illustration which tend, as we advance, to become more and more distinct, and that at one time we have under con-

sideration a specimen, the chief interest of which lies in its treatment as a painting, and at another time a specimen whose merit is altogether its value as a drawing. In a word, our manuscripts divide themselves into two groups, and at the point at which we have now arrived the line of division is clearly defined. In the one group we have miniatures which are true illuminations, works resplendent with gold and colours; in the other we have miniatures which are rather of the nature of illustrative drawings (not less artistic than the illuminated group, nay, not infrequently surpassing it in merit), in which colour, if used at all, is only sparingly employed. In some manuscripts we find both styles intermingled. Again, quite apart from the miniature, we shall also have now to consider the development of the initial and the border, which belong to the generally more mechanical department of book-decoration, but which, notwithstanding, play a most important part in the history of mediæval art.

We turn now to consider some of the examples of the illuminated group of miniatures, and our first is selected from an English manuscript of the 12th century of the Norman type (Royal MS. 2 A. xxii.), executed at Westminster, probably in the later years of Henry the Second's reign. Here again our manuscript is a Psalter, a favourite work for illustration at this period. The painting now before us is a most beautiful picture of the Virgin and Child, the drawing strong and bold, and the rich colours enhanced by a background of burnished gold, which now begins to make its appearance in illuminations. The features are pallid, and are worked up with white applied in a thick pigment, a method which seems to have found favour in England at this period, and which we find still marking English work at a later time. Certain distinctive colours, too, now first appear in our manuscripts, and often provide us with the means of identifying English work at a time when the styles of England, of northern France, and of the Low Countries bore a close resemblance to each other. We must not leave this fine manuscript without glancing at a particularly fine rendering of the enthroned Christ, on which the artist has surely concentrated his best efforts.

As in other branches of art, the transition from the style of book-decoration of the 12th century to that of the 13th century is very marked. The contrast between the broad drawing of the former period and the more meagre but still beautiful style of the later

time strikes the most casual observer. The large book gives place to the small one; the bold, round handwriting of the 12th century is exchanged for one narrow and compressed; and the large florid initial shrinks into the delicate little letter, with its artistic pendant, which we see so frequently in those minutely-written Bibles which were produced in hundreds in the 13th century.

One of the most interesting manuscripts of the latter century recently come to our knowledge, is a Psalter of about the year 1250, belonging to the Duke of Rutland, which was exhibited at the Society of Antiquaries two years ago. It was probably executed for the family of De Laci, and the locality of its origin may be in the west of England, not improbably in Shropshire. It contains, among others, a remarkably fine miniature, representing the scene in which Saul casts his javelin at David. This is, indeed, a most beautiful piece of drawing. Setting aside the stiffness which is characteristic of the time, nothing can be better than the general effect of the composition, and, in particular, than the graceful pose of the female figure in the background. The contrast with the broader style of the drawing of the Westminster Psalter will not escape observation.

We will now revert to the other group of manuscripts, in which outline-drawing holds the prominent place, and we find under our hands a series of volumes ornamented in this manner in the great monastery of St. Albans, so famous in the 13th century for the school in which the historian Matthew Paris is so great a figure. And first we select a drawing of the Virgin and Child (Royal MS. 2 B. vi.), which, though not reaching to the excellence of a finished work of art, is interesting as carrying on the old tradition of English drawing in the elaborate working of the drapery, and more particularly for the manner in which the features are treated, a manner seemingly characteristic of the St. Albans school. The date of execution may be about the year 1260. Next we take an example of historical illustration from the Life of Offa (Cotton MS. Nero D. 1), by Matthew Paris, who himself may have been the artist. In this drawing we see how good an effect is obtained by the strengthening of certain of the lines. But a real masterpiece is to be found in the same volume—a magnificent figure of Christ, sketched in rather faint outline, and slightly washed in the folds of the drapery. We have the rare satisfaction of knowing the name of the

draughtsman of this fine work—the mediæval artist, from custom or modesty, rarely giving his name—"hoc opus fecit frater Willelmus de ordine Minorum, socius beati Francisci, secundus in ordine ipso, conversatione sanctus, nacione Anglus." There is an interesting incident connected with this drawing. On the back of the leaf Matthew Paris negligently wrote some lines of notes, but, suddenly remembering the figure, he broke off and only added this memorandum: "Nichil amplius scribatur in hac pagina, ne deterior-etur ymago; quia pergamenum diaphonum est, et melius videri potest, si apponatur luci."

Here we leave the drawing of the 13th century; but there is a famous manuscript which, although it really falls within the boundary of the 14th century, yet has so much in it characteristic of the older sentiment, and which moreover contains such brilliant examples of both the styles which we have been discussing, the illuminated miniature and the drawing, that we will describe it at this point before turning to another branch of our subject. This manuscript is the well-known Psalter, called Queen Mary's Psalter (Royal MS. 2 B. vii.) from its having once belonged to Queen Mary Tudor. It is certainly one of the finest manuscripts of its period in existence, and probably one of the finest ever produced. The early part of the volume is occupied by an exquisite series of tinted drawings of scenes from Bible history, and, accompanying the text, are the most perfect miniatures in gold and colours and other illuminated ornamentation. The miniature of the Last Judgment is one of the finest in the volume, and contains within the page examples of the different methods of ornamentation practised by the illuminator of the period. The subject itself is in two compartments: in the upper one is Christ the Judge, seated on the rainbow and accompanied by angels bearing the instruments of the Passion, with the Virgin Mary on His right hand interceding for mankind, the background being of burnished gold; in the lower compartment the dead are seen rising from their graves at the sound of the last trump, the background being of a diapered pattern in colours. Again there is a group of adoring figures within the initial letter of the Litany; and, quite independent of the main subject above, one of those charming little tinted drawings with which the volume abounds is introduced into the lower margin, and represents Saul receiving the letters to Damascus for the persecution of the saints.

From the series of tinted illustrations of Bible history, which occupy the early part of the volume, we may select one representing the finding of the infant Moses by Pharaoh's daughter, and, in the lower compartment, an apocryphal incident of Moses, as a child in Pharaoh's Court, striking the son of the Egyptian king, who, as the inscription tells us, thereupon condemns him to death, but "*tote la Court prie pur ly.*" The drawing of the subjects throughout this manuscript is remarkable for its delicacy; and it will be observed that the graceful effect is much enhanced by the flexible pose of the figures, which is so characteristic of the period of the early 14th century.

The growth of the ornamental initial and border must now claim our attention. The marked change which came over the art of illumination in the 13th century makes that period a fresh starting point for the development of this branch of book-decoration. The illuminated initial, the body of which is filled either with a conventional design or, as often, with a miniature, is accompanied by a pendant which fills more or less of the margin. The design of this pendant is usually simple, a bar or rod, sometimes branching, and terminating in a grotesque or bud or incipient leaf. Such we may find in numbers in the multitude of small Bibles which came into vogue at this time. A good example occurs in a finely-written manuscript in the Royal Collection (1 D. i.) of the middle of the century. Of a more elaborate character are the borders of a manuscript (Additional MS. 24 686) executed for Alphonso, the son of Edward the First, who, however, died in 1284, before it was completed. But the advance in style is here rather due to the accessories, the actual border having developed only in a slight degree in the growth of the terminal foliage. But when we cross the threshold of the 14th century we at once are in presence of a great change; the bud or incipient leaf has now developed into a full-grown leaf, and the border creeps farther and farther round the margins of the page. It is at this time that the border which, in its 13th century form, was much the same in England and in France and in the Low Countries, assumes a national dress in those countries, each diverging from the others more and more as time proceeds. In England the border soon shows a tendency to develop into a solid frame, throwing out branches of foliage which become more and more conventional; but there are many varieties in intermediate stages between this final shape

and the simple form. We may select a good characteristic border of about the first quarter of the 14th century from a manuscript (Arundel MS. 83) which was executed in the eastern counties and probably belongs to a school of illumination which, as there is evidence to show, flourished at Norwich about this time. In this specimen we have the ornamental initial, within which is a miniature of the Trinity, throwing off from its upper and lower marginal corners foliated branches which are carried as a frame round the four sides of the text. Along with the conventional foliage, it is to be observed, the English artist was fond of introducing into his borders flowers and leaves, &c., in their natural forms. Thus we here have the daisy, a very favourite subject, oak-leaves and acorns, and nuts.

In order to conclude at this point what we have to say of the development of the border, we must break for a moment the chronological order that we have been observing and glance at the curious conventional shapes which the foliage of the borders in English manuscripts assumed at the beginning of the 15th century—a strange arrangement of clustering leaves and sprays of feathery and spoon-shaped leaves and flowers far removed from anything of the kind in nature.

We draw upon our manuscript of the Norwich school, a Psalter, profusely ornamented with miniatures, to illustrate the progress of the illuminated paintings of the period. The Crucifixion here depicted on a full page is a highly-wrought example of the subject conventionally treated, the figure of the Saviour retaining much of the feeling of the preceding century; but the figures of the Virgin and St. John being less severe. The back ground is a brilliant diapered field of gold and colours. And, again, from the same source the very charming group of the three living kings, in their encounter with the three dead kings, must not be overlooked, with its accompanying text in French and English.

To bring this period of our subject to a close, we will place upon the screen a single example of beautiful outline-drawing, which occurs in a series of illustrations in a French version of the Apocalypse (Royal MS. 19 B. xv.), written in England about the year 1330. It is a single figure, sketched in with a few simple lines in the most charming style: the mighty angel who "took up a stone, like a great millstone, and cast it into the sea, saying, Thus, with violence, shall that great

city Babylon be thrown down, and shall be found no more at all." Let us carry back our thoughts to the outline drawing of our Anglo-Saxon artists, and review in memory the development of that art as we have seen it pass before our eyes this evening, and none will deny that the draughtsman who could produce this drawing was not unworthy of those who had gone before him.

After this period there is a remarkable dearth of English illuminated manuscripts of a high order; and during the long reign of Edward III., as far as can be judged by surviving examples, there appears to have been a decided decline in the art of illumination. We have, in fact, to wait till the period of Richard II., when we discover a school of painting distinguished by its fine colouring and richness of decoration; and we have to pass towards the end of the century before we find a specimen of English illumination of real artistic merit. A great Bible of this period in the Royal collection (1 E. ix.) is splendidly decorated with miniature-initials and miniatures and borders representing the work of this school. The special characteristic of the style is the careful modelling of the features of the face, a characteristic which is noticeable also in the pictures of the time, together with brilliant colouring and a profusion of pounced gilding. In one of the initials, which stand at the head of the several books, there is a very finely-drawn figure of St. Jerome, which conveys a good idea of the excellence of the art of this volume.

Of the same period, but a few years later, is the famous Sherborne Missal, belonging to the Duke of Northumberland, one of the few manuscripts of which we know the names of both writer and artist. It is a large volume, executed at the Benedictine abbey of St. Mary of Sherborne, in Dorsetshire, at the beginning of the 15th century, probably at the expense of Richard Mitford, Bishop of Salisbury from 1396 to 1407, and the contemporary abbot of Sherborne, Robert Bruynyng, who held the abbacy from 1386 to 1415. The repeated occurrence of the figures of the bishop and the abbot, together, in several of the borders proves that they had a common interest in the work. The writer and the artist were both named John, and, curiously, their surnames were not unlike. John Was or Whas wrote the text, and John Siferwas ornamented the book or superintended its ornamentation. The latter was not, however, an inmate of the house, but a Dominican, and is known as the artist of at least another manu-

script. It is evident, from the way in which scribe and artist are constantly associated in details of the ornaments, that they had a humorous appreciation of the situation. Altogether the artist had the pleasantest portion of the task. John Whas, the scribe, had to plod on with his writing, while his friend was designing at leisure: "*Librum scribendo Jon Whas monachus laborabat; et mane surgendo corpus multum macerabat.*" But we are here concerned with the work of the artist, and select a page which was undoubtedly decorated by Siferwas's own hand, showing that he was not only skilful in the execution of the ordinary character of ornament, but also that he was a draughtsman of refined touch.

Some few other manuscripts there are, alas! too few, of the close of the 14th and beginning of the 15th centuries, which prove that the old artistic traditions of the English school of illumination were not forgotten; but the promise was not fulfilled. The wars with France and the convulsions of the war of the Roses seem to have extinguished the last efforts of the native artists; and henceforward the influence of the French style becomes so predominant that for the rest of the 15th century the English art of illumination is practically dead.

Here then we close our survey. As I have elsewhere observed, the student of the subject will find that from the earliest time there has been in this country no lack of either mechanical or artistic skill. "The wonderful decoration of the Irish school was practised successfully in the 8th century; and the free-hand drawing of our artists under the Anglo-Saxon kings was incomparably superior to the dead copies from Byzantine models which were in favour abroad. The artistic instinct was not destroyed, but rather strengthened, by the incoming of Norman influence; and of the 12th and 13th centuries there is abundant material to show that English book-decoration was then at least equal to that of neighbouring countries. For our art of the early 14th century we claim a still higher position, and contend that no other nation could at that time produce such graceful drawing. Certainly inferior to this high standard of drawing was the work of the latter part of that century; but still, in the miniatures and decorations of this time we have examples of a rising school of painting which bid fair to attain to a high standard of excellence, and which only failed from political causes."

DISCUSSION.

Mr. LIONEL CUST said he must express his gratitude to Sir Edward Thompson for having brought before them two very interesting specimens of English portraiture, one the portrait of Chaucer, which he thought it was a great pity was in the British Museum instead of in the National Portrait Gallery, and the other the extremely interesting portrait of Lord Lovell. John Siferwas was evidently an artist of genuine merit, and for any miniature painter of that day to have produced so real and definite a portrait—not a mere convention—was a great distinction for England. He did not know any other country which could show a portrait of so intimate and private a nature of such excellence at such an early date.

Mr. MATHEW WEBB remarked that in one of the photographs, in the lower portion, there was a scene representing a king, queen, and ladies seated at a table, and he noticed the figures showed complete through the table. He should like to know if in the manuscript itself it looked like an amendment of the drawing, or whether it was the artist's way of getting at the true proportions of the figures. The lower part seemed to exactly fit in with the upper part of the figures.

Sir EDWARD THOMPSON said he believed it was merely the drawing on the other side of the leaf showing through the vellum.

Captain YATES, R.A., said he noticed that in all the portraits of the Saviour as a child on the Virgin's knee, the right hand was held up with two fingers up and two down. Among Eastern nations, where he had spent a good many years, portraits were always drawn like that, with one hand held up.

Sir OWEN TUDOR BURNE, G.C.I.E., K.C.S.I., on behalf of the Society, expressed thanks to Sir Edward Thompson for his very interesting and instructive paper.

Mr. ALAN S. COLE said he also had been extremely interested in the paper, and he particularly admired the specimens of pictures shown in the lantern, which were so admirably selected.

Mr. WILLIAM GOWLAND said this was a subject with which he was not very familiar, but he should like to say one thing about the position of the hand, which had been referred to by Captain Yates. He should go a little further east than India; in China and Japan the holding of two fingers up and the other two and the thumb down was seen on Buddhist altar paintings, and when the chief founder—now canonized—of one sect of Buddhism was represented it was always in that attitude. The date at which that first appeared in Japanese pictures, which were

probably copied from earlier ones in China, was about the 8th century.

Mr. HUGH STANNUS said they were much indebted to Sir Edward Thompson for the admirable manner in which he had presented the facts. He had given a complete epitome of the illuminators from the early influence which came over through Scandinavia to Iceland and Ireland, and thence to Lindisfarne. He had been much struck by the similarity of some of the work to some of the early Mycenæan work. Obviously those early nations when they could use anything similar to compasses, like children with a new toy, were anxious to make the most of it, and they drew interlacing circles in all directions, filling in the ground between with colour. It struck him there was the same character in much of the Lindisfarne detail as in a good deal of the Mycenæan work. He would like the Chairman's opinion on that point. Again, in the Canterbury Psalter a great deal of the detail seemed to be Byzantine in character rather than Roman; he referred especially to the leafage and the manner in which the leaves were joined together without any stem or flower. That was more like what is seen in Oriental churches than the work seen in Rome or Pompeii. Might that not be considered as the result of some Byzantine MSS. which had come over. There was an interesting point about the pen work which struck him as a thing to which attention might be drawn. The drapery was very like the zigzag folds in archaistic Greek figures. Possibly there was communication with Byzantium as well as Rome, or some Byzantine work must have come through Rome to England, and if so that would be accounted for. With regard to the hand, in one of the beautiful slides shown on the screen, they were accustomed to suppose that the figure of the Saviour with the hand raised was in the attitude of benediction; they knew that the Western church blessed in the name of a Trinity, with three fingers up and two down, while the Eastern church blessed in the name of Jesus Christ, and it appeared to him that the fingers with the curious bend were rather intended for the Eastern form of benediction. If so that would be another reason for supposing there was some Byzantine influence at work.

The CHAIRMAN said it was not usual for the Chairman to answer questions put in the course of the discussion, but as he had been appealed to on two points he would do his best. First, with regard to the hand in the attitude of benediction. Curiously enough it occurred as the principal type on the reverse of a long series of Saxon coins, struck during the reign of Ethelred II., and it was thoroughly understood as the hand of Providence coming down with the two fingers extended in that manner, with Alpha and Omega on either side, showing really what was designated by the hand in that particular form. This was good evidence that at an early

period the hand in that position was considered to be the hand of Providence in the attitude of benediction. With regard to the art of Mycenæ, that would open up a very wide field for discussion, but he might say that, owing to the peculiar forms of ornamentation of some gold ornaments found at Mycenæ, they were at first attributed to the period of about A.D. 300 or 400, instead of 1200 or 1400 B.C., as they should have been. This was due to their great resemblance to what were known as late Celtic patterns. He had now to propose a vote of thanks to Sir Edward Thompson for the interesting paper he had given. They must all have felt that not only was the matter admirably arranged, but that the illustrations were excellent of their kind, and conveyed exactly what the author of the paper wanted to demonstrate. It was remarkable how in those early Lindisfarne documents you found a survival of the style of ornamentation which prevailed in this country before the Christian era. About the time of the Roman invasion, now known as the late Celtic-period, they had a number of highly ornamental objects, a few shields, but more especially mirrors; and at Glastonbury certain wooden vessels had been found decorated in a peculiar manner with outlines of circles—compasses having recently been introduced—and those portions were sub-divided by other circular lines and the spaces between were ornamented with cross-hatching. There was a peculiarly graceful and flowing character about this ornamentation, and some of the backs of the mirrors were very excellent samples of what could be done by means of a simple combination of a few curved lines, combined with a small amount of cross-hatching. There were also some brooches and ornaments on which there were spiral patterns closely coinciding with those found in some of the Lindisfarne ornaments, and that peculiar interlaced pattern which was found on the MSS., and also on the corners of stone crosses, a sort of basket-work pattern which seemed to have originated from the plaiting together of osiers, which prevailed very largely on the crosses in the north. At the same time that simple form of interlaced ornament was not entirely absent in Italy and other parts of the Continent. In all probability there was an interchange between north and south, quite as much as at present by the migration of monks and ecclesiastics from one portion of the dominion of Rome to another. The system of drapery, to which allusion had been made, was certainly of a Roman character, and it would be found from time to time, even in the Saxon period, that devices engraved on Saxon coins were derived from common Roman coins that were turned up in the soil; not unfrequently, the “wolf and twins” were struck at a period 500 or 600 years after the coins on which they originally appeared had been issued. There were other traces of Roman influence on the coinage, and coinage itself might to some extent be compared with the contemporary ornament, whether in sculpture or illustration, on MSS. What was known as the sovereign type of

Edward the Confessor, gave a seated figure with very well defined drapery, very much in the style of the MSS. of the time. There was that bold marking of the drapery which was very characteristic of the ornamentation of the period. The development from one stage to another, the influence of the different schools one upon the other, and the gradual development of a thoroughly English school, had been so well pointed out in the paper that he need not dwell upon it. He could only say that he had followed all that had been said with great admiration, and cordially concurred in all the inferences that had been drawn.

The vote of thanks having been passed unanimously,

Sir EDWARD MAUNDE THOMPSON, in reply, said with regard to the Byzantine feeling, which Mr. Stannus observed in some of the drawings, it was perfectly true that Byzantine art had a great influence on the art of Western Europe; but there was a broad division between the Anglo-Saxon drawing and that of the Continent: that is, that while the Continent was following what was the real Byzantine style, the source of English drawing was Roman, but still no doubt slightly influenced by the Byzantine school. If you took the manuscripts produced in the Frankish Empire of Charlemagne, and put them side by side with the English, there could be no hesitation in at once drawing the line between the Byzantine style and the classical style, meaning by the latter the Roman, as followed in the two schools.

Miscellaneous.

GOVERNMENT PURCHASE OF RAILWAYS IN SWITZERLAND.

At the election held in February last to settle the long and bitterly discussed question of the purchase of the five main railway lines of Switzerland by the Government, the total number of votes cast was 560,892, each citizen above the age of 21 having the right of voting. Of this number of votes 384,382 were in favour of, and 179,511 against the purchase, making a majority in favour of Government ownership of 207,871. The lines to be purchased are as follows:—Jura Simplon, Swiss North-East, Swiss Central, United Swiss, and Gotthard. On the 6th of December, 1891, the question of the purchase of the Swiss Central Railway was voted upon and the vote cast was 420,500. According to Consul-General Du Bois, of St. Gall, the number in favour of the purchase was 130,500 and the number opposed was 290,000, the majority against the purchase being 169,500. Thus it will be seen that there has been since 1891 a great change in the minds of the people of Switzerland concerning the Government ownership of railways, and this change has been brought about by a thorough discussion of the subject in the Press and on the

platform. The amounts estimated as being the cost of construction and equipment of the five main lines are as follows:—Jura Simplon, £10,900,000; Swiss North-East, £8,850,000; Swiss Central, £5,640,000; United Swiss, £3,050,000; Gotthard, £9,758,000, total £38,198,000. The total length is 1,700 miles, and the amount that the Government will have to pay for these roads is estimated at about £40,000,000. The total receipts in 1897 were £4,144,000. An average of 5 per cent. dividends have been declared during the past five years. The number of persons employed is about 25,000.

Correspondence.

STAINED GLASS AND MOSAIC WORK.

I feel myself quite unequal to contend on any point of practical art with my distinguished colleague in the Applied Art Section of the Society of Arts, Mr. Lewis Day, yet am strongly moved to most respectfully protest against his dilatation of the term mosaic to the inclusion in this class of artistic production of a stained, coloured, or painted glass window; which he deliberately says is "quite strictly a mosaic,—as much a mosaic as, for example, a Roman pavement." He indeed endeavours to draw a distinction between a window ornamented with a pattern in stained glass, and one decorated with a picture, as a scene from the lives of the saints, in pictorially stained, or, more strictly speaking, "painted" glass. But if you begin dilating technical terms, which are useless and misleading unless strictly contracted in their application, and unless they exactly, even if arbitrarily, define the things meant by them, you cannot consistently draw any real distinction between a pattern-painted window and a scene-stained window: and if ornamental writing, water-colouring, and "illumination," patterning and picturing in "oils," enamels, and coloured wax, embroidery and weaving, and mosaic work, are all forms of painting (and mosaic has been enthusiastically said to be "the only painting for eternity"), a patterned window is as much a painted window as is a pictured window, and no more a mosaic than a pictured window is a mosaic.

The truth is that the use of a transparent, however highly tintured, glass, instead of stone, or clay, or glass rendered opaque by being incrustated with gold, *i.e.* "Greek [Byzantine] glass" [with which St. Sophia's and St. Marc's are "glorious within"], makes all the difference, and the real distinction, between a stained or painted window and a mosaic. It is simply an abuse of terms talking of a window as a transparent mosaic. There is no such thing as a transparent mosaic; and there is no such thing as an opaque window, unless the term window is also to be extended so as to include a door! The word "glass" means primarily "transparent," like the "spacious firmament on high," and secondarily,

sky-blue ("French grey"); and radically it is the same word as glaze, glamour, glance, γλαυξ,* gleam, glimmer, glimpse, gloss (not "gloss," a commentary), glow, gloom, and glum, and glacier, and gladness, and glory; and we have the word also in such British place-names as Glaisdale, Glaslin, Glas-nevin, and (through "St. Kentigern," corrupted to Glaschu, "grey-hound") in Glasgow. Translucency, glow, gleam, and glamour, are of the very essence of decorative glass, and it is only when glass is rendered opaque, as in the Venetian [and old Roman] *miliefiori* that it is technically called "mosaic glass"! On the other hand, opacity is of the very essence of mosaic work, as is plainly indicated by its Greek designation ψήφωσις, "pebble-" or "cobble-work," and its original Latin designation, "pavimentum lithostrotum." Mosaic is a term of Low Latin origin, and in no work in late Latin on the industrial arts, is the term, so far as I am aware, ever applied to the ornamentation of a window with stained glass. The word is "mosaic," pertaining (not to Moses or to the *mosque* of St. Sophia, as have both been seriously said, but) to the Muses [*cf.* music,† museum], and therefore, etymologically, the word applies to anything ornamental or artistic; so that, if people will be untechnical, an oil painting, or a statue, or an opera, or my "calligraphy,"—any of these is a mosaic.

The earliest‡ description, of which I am aware, of a stained glass window is in Prudentius [A.D. 348—?410], who praising the beauty of the glass in the windows of the Basilica of St. Paolo fuori le Mura at Rome, built by Constantine,§ exclaims, "Thus the meadows laugh with the flowers of Spring" :—

"Sic prata vernis floribus reident."

These windows were evidently in the earlier Oriental style of decorative glazing, of which we have a very effective modern example in the windows designed and executed by Mr. C. Purdon Clarke for the little English church at Alexandria. Later, there is a description of stained glass windows, but whether pictured or not is perhaps ambiguous, in Sidonius Apollinaris [A.D. 431-482]:—

"Ac sub versicoloribus figuris‡

Vernans herbida crusta saphiratos,

Flectit per prasinum vitrum lapillos."

* Compare Aglaia, &c.

† In the romance of Parthenopex, we read:—

"Et sont d'or Musique aorné."

‡ Lactantius (De Opificio Dei) and St. Jerome, in the 3rd and 4th centuries, mention glass windows, but it is doubtful if their references are to coloured windows. After Prudentius and Sidonius, we have frequent references to, and descriptions of, coloured windows, as in Eraclius [10th century] De Artibus Romanorum, Rugerus ["Theophilus the Monk," 12th century] De Diversibus Artibus, and Alexius [16th century] De Secretis.

§ Enlarged by Valentinian II. and Theodosius, and burnt down 1823.

‡ In the church of St. Agnes at Rome there is an inscription, two lines of which are worth quoting in this connection:—

"Aurea concisis pictura metalli

Et complexa simul clauditor ipsa dies."

I cannot give the date of the inscription

Mr. Lewis Day justly stigmatises the affectation of people who "go on mumbling the old legend of 'lost secrets' in the art of glass-making." It is due partly to the old confusion of the craft-term "mystery," which is but "magistry" or "mastery," or, as some have it, "ministry," with "mystery" (*cf.*: mum, mute), a "secret" revealed only to the initiated, and hidden from the profane vulgar. There is the same confusion in the use by ignorant persons of the phrase "mystery play," which but means a play acted by "craftsmen."

Yet there were "masteries," long laid aside by us, in the framing of a glass window, which might be revived with advantage; and one was the dividing of the coloured plates of glass with red hot pincers, instead of with the diamond. The present practice is said to have originated in a lover's quarrel between Francis I. and the Duchess d'Etampes. In his anger he scratched deeply with a diamond ring on a pane of glass, still preserved at the Chateau Chambord, the well-known lines:—

"Souvent femme varie,
Mal habil qui s'y fie."

It is a charming story, and all the modern mode of cutting stained glass has to recommend it.

GEORGE BIRDWOOD.

Our Lady's Day,
1898.

P.S.—THE GOLDEN "AMPULLA" OF THE BRITISH REGALIA.—With reference to the suggestion I threw out in the discussion on Mr. Cyril Davenport's paper on the "British Regalia" that, the golden "ampulla" said to have been expressly made for the coronation of Charles II. might not have been intended to represent, as is usually said, an eagle, but a dove, "the anointing dove,"—a suggestion I held to be supported by the tradition of the original "ampulla" used in the coronation of Henry IV., 13th Oct., 1399, having been a gift of the Virgin Mary—I find that a similar tradition existed in Old France regarding *la sainte ampulle* kept in the tomb of St. Remy in the cathedral at Rheims, for use at the coronation of the French kings. According to the legend, this true ampulla—a glass phial—was brought down from heaven by a dove, for the baptism and coronation—by St. Remy—of King Clovis, A.D. 496. The phial was broken to pieces by the Revolutionists in 1793; but its contents, the consecrated semi-solid *chrism* of mixed balm and frankincense, were, however, saved by the Abbé Seraine, and were used at the consecration of Charles X. in 1825. They are still preserved in the original shrine in the cathedral of Rheims. After this, I feel certain that the "ampulla" of Charles II. was never intended—or only of "second-hand intention," as

"When things by wrongful names you mention"—
to be an eagle: and in form it is not an eagle, any

more than it is a dove, but a plucked turkey, or rather fowl—*la sainte poule*, in fact.

All Fools Day,
1898.

GEO. B.

STAINED GLASS WINDOWS.

Mr. JOHN LEIGHTON, F.S.A., writes:—In "the making of a stained glass window," the great difficulties the designer has to contend with are the leadings and the obscurations of light by the stanchions that grin at you from the interior, and are hardly decorative from the exterior, a defect that could not be overcome unless the leads were gilt and the stanchions painted brightly, to come forward instead of retire as they now do, and thus overcome their sombre aspect; for, say what you will, the windows of ecclesiastical edifices as seen from the exterior by daylight are melancholy objects—objects that the French painters *sur verre* have sought to overcome by using glass that, whilst transparent, is to a certain extent opaque, and I have now before me some samples well suited to the sunny south, though prohibitive here, where the sun is seen so seldom.

A propos of leading and the use of iron stanchions, I might note that in 1851, Messrs. Pilkington, of St. Helen's, exhibited at the First International Exhibition plates of painted glass in single sheets designed by Mr. Frank Howard and by myself, the same having been fired many times, the only objection to huge single plates being that in case of fracture, all was lost. We might have our railway stations enlivened by maps, views of towns, or even pictorial posters, that should be agreeable in colour, and at the same time instructive; but these features should be free from shade and dependent upon hue alone, that light may freely enter, somewhat like the Japanese colour prints so copied in the present day, and not unlike the lights in single sheets that I exhibited at the Royal Academy many years since, prior to their being done by Pilkington, for Holford-house, on the single plates.

General Notes.

SCIENCE ABSTRACTS.—A new periodical entitled "Science Abstracts: Physics and Electrical Engineering" (of which two numbers have been issued), is published monthly under the direction of the Institution of Electrical Engineers and of the Physical Society, and the hon. editor is Mr. J. Swinburne. The arrangement of the abstracts followed in each number is as follows:—General Physics, Light, Heat, Sound, Electricity, Electro-Chemistry and Chemical Physics, General Electrical Engineering, Dynamos, Motors and Transformers, Power Distribution, Traction and Lighting, Telegraphy and Telephony. Each number contains over one hundred abstracts of papers in the chief foreign and English journals.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Proceedings of the Society.**INDIAN SECTION.**

Thursday, March 31; Sir DENNIS FITZPATRICK, K.C.S.I., Member of the Council of India, in the chair.

The CHAIRMAN, in opening the proceedings, said to many of those present, and especially to those who had been in Assam, Mr. Luttman-Johnson needed no introduction. For a larger number of years than usual, he occupied a high and important position there, and was known, not only as an official of great ability, but also as a man of great powers of observation, and of deep sympathy with the people. He also possessed in an unusual degree the faculty of graphic description, so that he could arouse interest in whatever subject he dealt with. He felt sure, therefore, that his paper would be both interesting and instructive.

The paper read was—

THE EARTHQUAKE IN ASSAM.

BY H. LUTTMAN-JOHNSON, I.C.S.

CONTENTS.—Description of Assam—Geological description—What an earthquake is—Earthquake origin—Depth of origin and velocity—Assam an earthquake area—Former earthquakes—This earthquake the most violent—Effects of earthquake at principal stations: Shillong, Mr. McCabe, Gauhati, Sylhet, Tura—Experience of civil surgeon of Goalpara—Conduct of native servants—Conduct of native population—Further troubles—Message from the Queen—Behaviour of animals—Damage to roads and railways—Tea gardens—Effects in Bengal—Fissures—Geysers—Upheaval of river beds—Buildings—Extension of earthquake—No seismological result—Conclusion.

DESCRIPTION OF ASSAM.

I propose to take you this afternoon to rather a remote corner of India—indeed, a remote corner of the earth. If you will turn your mind's eye to the map of our great dependency, you will see that to the north-east it overlaps Burmah, the Straits Settlements, &c. Here the red line which distinguishes British territory extends almost to the western borders of

China. The overlapping corner is the British province of Assam. It is bounded on the north by the Himalayan mountains, on the east by hills bordering on China and Burmah, on the south by Burmah and the huge province of Bengal, on the west by the same province. The province consists of two valleys running east and west, with a range of hill country rising some 5,000 feet above the sea between them. It also contains within its limits a large stretch of hill country on the confines of Burmah, while the hill tribes of the Himalayan mountains on the north and north-east are more or less within its administrative group. The northern valley is that of the great Brahmaputra river, which, after draining a large part of Thibet beyond the Himalayan mountains on the north, breaks through those mountains nearly due south, and then flows west by south till it reaches the province of Bengal. The southern valley is named after its principal river the Surma. The northern valley is some 450 miles long from east to west, and from 60 to 40 miles broad; the southern is only some 150 miles long from east to west, and about the same breadth as the northern valley. But though the northern valley is so much the larger, the populations of the two valleys are about the same. Something in the climatic conditions of the northern valley militates against increase of population and cultivation, whereas the southern valley is almost fully populated. The northern valley is inhabited by a mixed population largely Mongolian in origin; the southern tract is inhabited by Bengalis. The hill tract lying between the two valleys is very sparsely inhabited by very interesting and very primitive peoples.

Formerly these outlying parts were under the Government of Bengal, but in 1874, partly in order to relieve that Government, which was thought to be too large, partly because it was thought that these backward, undeveloped tracts suffered from their union with the strictly regulated province of Bengal, they were constituted into a separate province. The upper part of the northern or Brahmaputra valley had long been called Assam, a name perhaps derived from the Ahoms, a people of Shan origin, who ruled there in former times. To the natives of Hindustan this old Assam is an uncanny, ill-omened land—a land of mysteries and terrors, not probably on account of its earthquakes or its plagues, but rather because it is either non-Hindu or only superficially Hinduised. The name is well known in this country because the province produces tea in

large quantities. The cultivation of this product has brought a large number of European settlers to the province. It is rather a British colony than an Indian province, so prevalent is the tea industry. No other part of India owes so much to this class.

GEOLOGICAL DESCRIPTION OF ASSAM.

Both the northern and southern valleys are more or less alluvial. The eastern end of the southern valley is deltaic. Both valleys are probably areas of subsidence. The central range is composed of more or less hard crystalline rocks, through which an earthquake shock would be transmitted with great readiness.* The geological character of this central range connects it rather with Western Bengal and the peninsula of India than with the Himalayas on the north. The Himalayan mountains are composed of indurated rocks, also well adapted in themselves for the transmission of earthquake shocks, but mountain ranges are found to form a barrier to the transverse progress of earthquakes, probably because the shocks have to cross the strike of the strata flanking them. The southern face of the central range presents some very remarkable phenomena of upheaval or subsidence. Coal is found elevated to a height 4,000 feet above the level of the sea, accompanied by a series of rocks, limestone, and sandstone, similar to that at the base of the hills a few feet above the sea level.† It is probable that this entire group of strata, both that part which is now at the top of the hill and that which is at the bottom, some 2,000 feet thick, was deposited and formed in water of no great depth. Subsequently, either the northern part of the group was elevated to its present position or the southern part subsided. It is probable that the present steep southern face of this central range is formed along a great line of fault.‡ I mention this because the majority of earthquakes are probably due to faulting, and the origin of the recent earthquake is supposed to lie somewhere in this region. The alluvial deposit too in this part below the hills exhibits signs of upheaval or subsidence.¶

WHAT AN EARTHQUAKE IS.*

The description I am about to give of the Jubilee earthquake in Assam will only be intelligible to those who know what an earthquake is. As many of you have probably not studied seismology, I will explain as shortly as possible what an earthquake is. When a blow is given to any elastic body or material, the blow—that is, the wave or impulse generated by the blow—travels through or along the body or material; in other words, the particles which form the body or material first struck have pushed forward the particles immediately in front of them, which in their turn, after communicating the motion to the particles in front of them, again return to their original position, and so on. Now imagine an explosion of some kind to take place at some point inside an elastic material. The impulse or elastic wave generated by this explosion will travel from it in the manner I have described in all directions. If the explosion occurs in the centre of a sphere of homogeneous material, its impulse or wave will touch the outside at all points at the same time. The sphere will be distended as a bladder blown out with air, and will then again contract. What we call an elastic wave is rather a backwards and forwards pulsation or vibration, and must not be confounded with waves of water which depend on the action of gravity. It is propagated in a manner similar to that in which sound vibrations are propagated. Now suppose the blow to be struck not in the centre, but at some point near the surface of the sphere. The vibration will reach the outside of the sphere at the point nearest to the blow vertically, at all other points at an angle greater or smaller according to the distance from the vertical point. Imagine a marble consisting of a number of concentric shells inside a football, each shell representing a vibration, and let the blow be struck in the exact centre of the marble. The vibration or impulse will reach the crust of the football first vertically at the point where the marble touches it, and it will come out on the outside of the football through the crust just opposite that point. It will reach other points of the surface of the football later, and at a greater or less angle, according to their distance from the vertical point. This vertical point is called by seismologists the epicentrum, the point where the blow is struck or the explosion occurs

* "Cachar Earthquake, 1869," "Memoirs of Geological Survey," vol. 19, p. 86.

+ "Memoirs of Indian Earthquakes," "Journal Asiatic Society of Bengal," vol. 12, part 2, p. 1044.

‡ Oldham, "Geology of Khan Hills," pp. 48-49.

¶ Oldham, "Geology of India," p. 443. Medlicott, "Shillong Plateau," "Memoirs of Geological Survey," vol. 7, p. 135.

* "Earthquakes" (Milne), vol. 56, "International Scientific Series," chapter 3.

the centrum or origin, the line joining these points the seismic vertical. The angle at which the wave comes out on the surface of the earth is called the angle of emergence. The emergence of waves of elastic compression on the surface of the earth causes the undulations so familiar in earthquakes.

Of course the earth is in no sense a homogeneous medium like the air in a football or the material of a marble. The elasticity of the parts of which it is composed varies enormously, and the parts themselves are permeated by fissures and faults. It has been calculated that nearly seven-eighths of the full velocity of the earthquake wave due to the material if solid and continuous is lost by reason of the heterogeneity and discontinuity of the rocky masses as they are found piled together in nature. This want of homogeneity of course affects the so-called waves in many different ways, which I have not time to explain. Then the original blow or explosion may be of various kinds. For instance, a long break or fissure would produce waves differing from those produced by a short one. Lastly, we may have waves not only of elastic compression, which I have described produced by alteration of volume, but also waves of elastic distortion produced by alteration of shape. From all which you will readily understand that earthquake motion is an extremely complicated phenomenon—indeed, an earthquake is rather a thing of freaks and eccentricities than of law.

EARTHQUAKE ORIGINS.

When an earthquake occurs we are told that the first thing we have to do is to find out where it originated, so that we may be able to avoid that part of the country, or at least make arrangements for future earthquakes emanating from the same origin.

In order to find out where an earthquake originates, we must observe its direction. If in one place to the west, the direction is from east to west, in another place further east, from west to east, we infer that the origin is situated somewhere between the two places. Personal observations of direction are extremely unreliable. But in the absence of recording instruments we can generally get a good idea of direction from the way in which walls, columns, and other objects have been overthrown, or fractured, or projected.*

DEPTH OF ORIGIN AND VELOCITY.

Seismologists take great interest in ascertaining the depth below the surface of the earth of the origin and the velocity with which the wave is propagated. If we know the angle at which the wave emerges on the surface of the earth at different places, we can easily calculate the depth from which it is propagated. This angle is calculated from the inclination of fissures produced in buildings. It is assumed that these figures are at right angles to the direction of the shock.* Again, if we have accurate records of the time at which an earthquake reaches different places we can calculate its transit velocity, that is the speed at which the wave or impulse above described travels along or, rather, emerges upon the surface of the earth.† It is obvious that these calculations must always give very uncertain results. In the present case we have no cracks. When the Director of the Geological Survey telegraphed to be sure to observe and record all cracks in walls, the answer was, "There are no walls left."

The final results of the investigations made by the members of the Geological Survey of India into the Assam earthquake have not yet been published. From preliminary investigations it is supposed that the centrum of the Assam earthquake was somewhere west of the line joining Shillong and Sylhet, in the region of the great upheaval or subsidence which I have noticed.

Professor Omori, a Japanese seismologist, who was deputed to Assam to make enquiries into the earthquake, thinks it originated 20 miles below the surface. The famous Japanese earthquake of 1891 was found to have an origin 5 miles below the surface. While the intensity of that earthquake was four times that of the present one, the area of greatest disturbance in the present case is four times greater than it was in the Japan earthquake. From this the Professor argues that the origin of the recent earthquake is four times deeper than it was in the case of the Japan earthquake. Other big earthquakes have been found to originate from 5 to 30 miles below the surface of the earth. One has actually been traced to a depth of 50 miles.

The velocity is said to have been 10,000 feet per second, or 112 miles per minute. Other

* "Earthquakes" (Milne) vol. 56, "International Scientific Series," p. 69.

• "Earthquakes" (Milne) vol. 56, "International Scientific Series," p. 213.

+ "Earthquakes" (Milne), vol. 56, "International Scientific Series," p. 87.

famous earthquakes have had much smaller velocities, from 2,000 to 3,000 feet per second. But more recent earthquakes in Japan, where systematic observations have been carried on under the Earthquake Department, have produced velocities up to 9,000 feet. Telegraph signallers prove useful recorders of velocity. In two instances in Bengal where the quake was travelling east to west, telegraph stations west were working stations east. There was stoppage due to earthquake at the east station, and almost immediately afterwards the quake reached the west station.

ASSAM AN EARTHQUAKE COUNTRY.

As a rule, earthquakes are most frequent in volcanic districts. The Malay Archipelago is one of the volcanic districts of the world.* In Java, in Sumatra, there are many active volcanoes. North of Sumatra, we still find volcanoes, first Barren Island, which is a true volcano; then, on the coast of Burmah, the mud volcanoes of Ramree Island, with Cheduba close to it in latitude about 19° . Near Chittagong there are many hot and cold springs giving forth inflammable gas. Further north, however, towards Assam, and in Assam, though there are hot springs and one mud volcano, there are no true volcanoes, either active or which have been recently active. Still, though not a volcanic tract, earthquakes are no new things in Assam, or indeed on the east side of India. The late Mr. Oldham, of the Geological Survey of India, compiled a list of Indian earthquakes observed without the aid of instruments.† In this list I find 110 earthquakes recorded as having occurred in Eastern Bengal, Assam, and Burmah, up to 1869. In Assam alone in the twenty years ending 1869 there were some fifteen. This is, no doubt, a very incomplete list. We have only been 150 years in Bengal and 75 years in Assam, and before our time there was no systematic record of such events. In an old diary I find eleven earthquakes occurred at Dilvooghar, at the upper eastern end of the Brahmaputra Valley, between January, 1839, and September, 1843. All of these came from the south-west, indicating an origin in the central hill trail.

Even in quite recent times, the record has been very incomplete. It is only recently that columnar seismometers have been in use. This seismometer consists of a series of round columns or cylinders of wood, or other

material, placed on a level plane and surrounded by soft material to prevent their rolling when they fall. The number and diameters of the columns overthrown measure the intensity, while the direction of their fall gives the direction of the shock. Such seismometers are not sensitive to slight shocks, and even where the shock suffices to overturn one or more columns, the information given is not wholly reliable.* A long-continued gentle shaking may overturn a column which would stand a very considerable sudden shock. Then earthquakes often give columns, gravestones, &c., a rotatory motion, which results in the columns falling in different directions. Besides the direction of motion of an earthquake seldom continues the same throughout the disturbance. So far as earthquakes of sufficient intensity to be recorded without the aid of instruments are concerned, we should have a complete record for the last 24 years, for the first Chief Commissioner opened a register of them in 1874. I think this was the first official notice taken of such phenomena. The results of the record thus established have not, I am sorry to say, been published. In Japan, where earthquakes have been carefully recorded for 2,000 years, there are from 20 to 40 more or less destructive ones in a century, and many of these are local; that is, are felt in particular localities only. Besides these there are something like two a day of sufficient intensity to be recorded without the aid of instruments. During the 18 years I was in Assam, I can recall some half-dozen more or less destructive earthquakes which is not far behind Japan. But in minor earthquakes, Japan is clearly *facile princeps*.

FORMER EARTHQUAKES.

Among large earthquakes in Assam and neighbourhood, I may mention the following. I omit that of 1737, which, in Mr. Oldham's list, is alleged to have caused the steeple of the principal church in Calcutta to sink into the ground, because it is now thought that the steeple was blown down by a cyclone and buried in mud by a storm-wave—a curious and interesting instance of the growth of myth.

A very bad earthquake which occurred in 1762 has become classic, that is, is referred to in all the text-books.† It was specially violent at Dacca and Chittagong in Eastern Bengal, south of the present Province of

* Lyell's "Principles of Geology."

† "Memoirs of Geological Survey of India," vol. 19, p. 163.

* "Earthquakes" (Milne), p. 16.

† "Journal of Asiatic Society of Bengal, 1843," vol. 12, part 2, p. 1044.

Assam. At the latter place the ground opened, throwing up water of a very sulphurous smell. The water gushed out prodigiously. In the chaise road, that is, the driving road, there were great chasms 2 feet wide and upwards. The bungalows (that is, houses of wooden frame and lath-and-plaster walls) proved very convenient on so melancholy an occasion. Brick houses must inevitably have been shattered and levelled to the ground. There was not a brick wall or house but was either greatly damaged or fallen. Anticipating the theory that an earthquake is an abortive attempt of pent-up forces to free themselves, the observer, hearing that two volcanoes had opened out, expresses a hope that they will prove a sufficient vent to discharge all the remaining sulphurous water in the bowels of the country.

There was another very severe earthquake in the eastern part of India in 1842.* This does not appear to have been very violent in Assam, though the focus of the seismic force lay at some distance north-east of Calcutta, that is towards Assam. We read this earthquake was accompanied by a noise which at first resembled some mighty rushing wind and then the loud rattling of carriages over a stony street. Again, in 1869, there was a very serious disturbance, of which we have an admirable account by the late Mr. T. Oldham, of the Geological Survey of India.† The centrum or origin of this earthquake was traced to the northern edge of the hill tract which I have described as forming the centre of what is now the Province of Assam, north-east of the head-quarters station, Shillong. Its velocity was found to be some 7,000 feet per second. Several places in Assam, especially Carbuc, at the eastern end of the southern valley, suffered very severely. At Shillong, a good deal of damage was done. A prominent feature of this earthquake were fissures and openings throwing up sand and water.

Again, there were destructive shocks in 1876 and 1885. The centrum of this last was some 200 miles north-east of Calcutta, some 60 miles south of the western end of the central range of Assam.‡ This earthquake did great damage in the parts of the Province of Bengal adjoining Assam. And there were many other shocks during the eighteen years I served in Assam, so that one came to regard them almost with contempt.

THIS EARTHQUAKE THE MOST VIOLENT.

But no earthquake, so far as we can judge, has ever been so violent, or has wrought such havoc as the one I am about to describe this afternoon. As regards more recent earthquakes, this is abundantly proved by the descriptions we have of them, and by the fact that many buildings which have succumbed on this occasion have resisted former attacks. And in regard to more ancient times, we have strong negative evidence. There is a very curious set of stone monuments at Demapur, on the northern edge of the central tract, probably set up by some primitive people ages ago. These have been twisted, broken, and overthrown by earthquakes in former times, but such an earthquake as the recent one would have wrought much greater destruction. Again, monoliths or menhirs set up by these primitive people in honour of deceased ancestors, who are supposed to have benefited them, are a prominent feature of the hill tract, which I have said forms the centre of the province. Probably in no country are menhirs more numerous.* Many of these are very ancient. They are now broken and snapped; in some cases they have been torn out of the earth. Those of you who have seen the Druidical stones at Stonehenge and at other places in these islands can form a good idea of what this means. A massive stone bridge, of great antiquity, in the Brahmaputra Valley has been destroyed. Very careful geological surveys, especially of the central hill tract, have not disclosed traces of such a catastrophe within historic time. Lastly, had such a catastrophe occurred, the people would have a tradition of it.

EFFECTS OF EARTHQUAKE AT PRINCIPAL STATIONS.—SHILLONG.

I will first describe the earthquake and its effects at four of the principal stations in the province.

And first of Shillong, the head-quarters station. When the Province of Assam was first constituted in 1874—though Calcutta is the natural business capital of these outlying parts, especially so far as the tea interest is concerned—it was thought necessary to find a local head-quarters within the limits of the new province. The chief town in the northern valley which had been the head-quarters of the Commissionership of Assam was Gauhati, very picturesquely situated on the

* "Journal of Asiatic Society of Bengal, 1843," vol. 12, part 1, p. 286.

† "Memoirs of Geological Survey of India," vol. 19.

‡ "Records of Geological Survey of India," vol. 18, p. 210.

• Fergusson's "Rude Stone Monuments."

river Brahmaputra. The southern valley is administered from a small town called Sylhet, about 120 miles south of Gáuhati. These places are difficult of access from the other valley; neither of them offered special advantages as a head-quarters station. But about midway between these two places, in the centre of the central hill tract, there already existed a small hill station called Shillong, lying about 5,000 feet above the sea. This was chosen as the capital of the new province. Though remote from the haunts of men, it had advantages over Gáuhati and Sylhet. It was more central; the water supply was much better. Wood, and lime, and stone for building were near at hand, and it had a temperate climate suitable to European constitutions. It was not more liable to earthquakes than Gáuhati and Sylhet, and other places in the province. Public and private buildings were rapidly erected, roads were laid out, and the lake, called after the former Commissioner of Assam, Colonel Hopkinson, was improved. Though a place so remote could never become a business centre or attract population, still when the catastrophe occurred Shillong had become quite a flourishing little station. It is very prettily situated amid fir woods at the northern foot of the watershed of the central range. It had its church, its assembly-rooms, its cricket field, its polo-ground, its racecourse—everything in fact which our countrymen in their exile think necessary to their comfort. It had its little bazaar, with some fifty shops, which sufficed to supply the wants of the small community. The waters of the neighbouring watershed had been conducted over the station in pipes from a reservoir for drinking purposes, and in silver streams for general purposes. The houses of the European residents, each in its own compound or enclosure, were perched about the hills, wherever a good view or picturesque surroundings suggested a site for building. Unlike Himalayan hill stations, where only jinrickshas and doolies are possible, it had good driving roads.

In a few seconds, this pretty little station which our countrymen had devised for themselves, was demolished. The earthquake took place at 5.11 to 5.12 (local time) on a Saturday afternoon, June 12th. The shock, which was preceded by the rumbling underground noise so familiar to dwellers in earthquake countries, lasted some three minutes.

The undulations appeared to be principally from south-south-west to north-north-east, as indicated by the direction in which pillars and

lamp-posts fell. At first the motion was slight and undulatory, but as the intensity increased it changed to a violent rocking from side to side, accompanied by upheavals. The earth was like some vast piece of machinery in motion so violent and regular was the action.

The largest of the cylinders of the seismometer which I have described was 9 inches in diameter and 12 inches high. It has been calculated from the overthrow of this pillar that the violence of the shock was at least equal to a backward and forward shaking of 7 inches repeated 60 times in a minute. An ordinary small earthquake produces a horizontal motion of a few millimetres—a fair earthquake perhaps 50 millimetres or two inches. As instances of effects produced I may note—(1) marble slabs were pushed from the tops of masonry tombs; (2) heaps of broken road metal by the roadside were scattered out in layers of a few inches deep; (3) masonry boundary pillars only two or three feet high were shaken to pieces.

The following graphic account, written by a young lady, was published in one of the Anglo-Indian newspapers:—

“It was a quarter-past five on Saturday afternoon, the 12th of June. After raining hard for two days and nights the weather had cleared, and the afternoon was lovely. Not a cloud in the sky. My sister and I started out on our bicycles for a ride, intending to call at the post-office on our way to post the English letters. Just as we were starting, my sister remarked what a dreadfully close hot afternoon it was; so unlike the usual weather at Shillong, and not a breath of air, but we thought it lucky having no rain. We started off up the hill towards the post-office along the road by the side of the lake. When we had gone about 300 yards up the hill I suddenly heard a dreadful roar. I couldn't make out what it was. It sounded like a train, thunder, and landslip all together, and it came nearer and nearer, and then the ground began to heave and shake and rock. I stayed on my bicycle for a second, and then fell off, and got up and tried to run, staggering about from side to side of the road. To my left I saw great clouds of dust, which I afterwards discovered to be the houses falling and the earth slipping from the sides of the hills. To my right I saw the embankment at the end of the lake torn asunder and the water rushing out, the wooden bridge across the lake break in two, and the sides of the lake falling in; and at my feet the ground cracking and opening. I was wild with fear, and didn't know which way to run. It seemed as if it would never stop, and my one idea was that it was the end of the world. I hoped it would be over quickly, and was expecting the ground to open and swallow me up. And then it ceased. I thought it had lasted fully ten minutes, but it had only lasted about 30 seconds. I

ran as hard as I could with my sister to a friend's house a little way off, and to my horror the house was levelled with the ground, not a stone standing, and Government House, to the right, was the same. Then I knew that Shillong must be absolutely wrecked I started off alone to try and find my father and mother, who were out driving. As I went along everywhere it was the same—not a house standing, and people were rushing about, wives looking for their husbands, parents looking for their children, everyone stricken with terror, no one knowing whether those belonging to them were dead or alive. I then rushed on to the cricket ground, where I found a crowd of people collected. They had all been told to go there, because everyone expected another shock, and that was considered the safest place. There were some who had been ill in bed, and had rushed out in their nightgowns with bare feet, and some half-dressed, some crying, and some in hysterics—everything in the wildest state of confusion. And then the rain came and it poured. This seemed extraordinary, because before the earthquake there was not a cloud to be seen, and five minutes afterwards we were surrounded with cloud and mist. Then everyone started looking for shelter, and half of us went to the cricket pavilion, which was built of wood and had stood, and half went to a row of thatched sheds which were usually used as a bazaar; they were also wood. The next thing to be thought of was shelter for the night, and the Gurkha soldiers managed to dig out some tents and put them up, and a few went into them, but most of us preferred staying together in the pavilion, where we sat up on benches all night, with the rain beating in on all sides. Continual small shocks made us think it was all coming over again. At each shock everyone got up and rushed out of the pavilion for fear it would collapse. At about nine o'clock some of the men managed to boil some chicken and rice for us, but everyone seemed too frightened to eat. The night seemed as if it would never end, and we all longed for daylight. At last it came, and most of the energetic ones went off to see if they could dig out any of their clothes and other belongings, but others were too unnerved to stir. Most of the men behaved splendidly. The morning dragged on to the afternoon, and then came more anxiety. The natives prophesied another earthquake at the same time that afternoon, and there were several severe shocks. The shocks never seemed to cease; they came about every ten minutes all night and day. By degrees one got used to them, and didn't jump up and rush out. Then came another night not nearly so bad as the first. Nearly all of us turned into tents and slept on mattresses on the ground, but the damp and rain were dreadful. There had been no time to dig trenches round the tents, and the ground was soaking. I slept on a mattress which was wringing wet, in my wet things. It was two days and nights before I was able to change my things. All the time they were wet through. Some people had managed to dig out some of their clothes,

and, therefore, were better off, but those who were in their nightgowns and could only manage to get a cloak to wrap themselves in, suffered dreadfully. Day by day things cleared up. Shocks grew fewer and fewer. News came in from the surrounding country telling people that those belonging to them were safe, and that other places, excepting one or two, hadn't suffered as much as we had. Then small huts were built for us in or near our own houses, where we could superintend the digging out of our things. The first post that came in caused tremendous excitement, and when the telegraph wires were mended, and communication restored with different places, everyone felt happier."

A lady who was nursing a young officer ill with typhoid fever thus details her experiences:—

"When the window of the room began shaking, my patient jumped up and screamed out, 'What is it? what is it?' I said, 'Keep quiet; it's only a thunderstorm.' At the same time I could hardly stand. The whole floor was heaving. There was an awful creak, when my patient sprang out of bed and made for the door. At the same time I saw the ceiling give way, and I only just dragged him back and pushed him down by the side of the bed and flung myself over him, when the chimney came crashing through and a big almirah fell at the back of me. I was struck on the back by a brick. For some minutes there was a dead silence, and we were choked with dust, the ground heaving up and down. I began to say the Lord's Prayer, and then shouted at the top of my voice. After some minutes I heard the bearer calling to me to say he could not reach me. I called out, 'Go to the window,' and then I struggled for life. I got free, and half-dragged, half-lifted my patient to the window. He could not help himself a little bit, and how I got the strength I don't know. After squashing him through the window, I tore off the blankets and shouted to them to take him off the wet grass. They shouted to me, 'Come out,' but I felt I must get him some clothes, which were on the other side of the room. I said, 'Get him brandy. I'm coming. Take him off the wet grass. He is dying.' I had just got the things I wanted, when another shock came, and in came the wall, the rest of the chimney, and the roof, and barred my way to the window. I made up my mind I must die like a rat in a trap, and shouted, 'I can't get out.' Then I heard a servant calling me to come out, and again I made a desperate struggle, and got to the window, where I stuck. I don't know how I got out, but I was nearly dragged to pieces. It was so tiny a space. It was pouring with rain, so I made a little hut of rugs and a chair and got the patient in, and for an hour I stood in the drenching rain, when some gentlemen and the doctor came to say the only refuge in all the station was some sheds which were used on market days in a swampy place called Laban. We made a hammock of rugs, and I

took my patient down with the help of some coolies, and there we poor half-drowned mortals huddled for ten awful days."

A lady writes:—"We were out walking, we clung on to trees, so violent were the shocks that we were sent from tree to tree."

Every masonry building in Shillong was levelled with the ground, not by overthrow but by a shattering of the walls into fragments on the top of which the roofs subsided. You will remember I said it was calculated there was a backward and forward movement of 7 inches every second. Most of the buildings were built of rubble masonry filled in with mud, with dressed stone at the corners, in the doorways, windows, &c. Some of the Government buildings were built of solid masonry. All these came down. Besides these there were many buildings consisting of a wooden frame filled in with lath and plaster. These fared much better, but even these were all shaken to pieces. The hotel (the little station boasted of one hotel) is a curious instance of this distinction. The centre building, built of masonry, is levelled to the ground; the wings, built of wood and lath and plaster, have survived, though much shaken and knocked about. The roofs of the houses were either of corrugated iron or of thatch. The station had so often suffered from earthquakes that it was not considered safe to build upper storied houses. The only building with upper stories was the Government printing press, the fall of which unfortunately caused the loss of ten lives.

The Deputy-Commissioner of the district, who it is satisfactory to learn has been rewarded with a decoration, thus describes the events of the first night after the earthquake:—

"The secretary's residence on the hill above the lakes, in which my wife and I were living, collapsed at once as we stepped out on to the lawn, and the magnitude of the disaster was revealed immediately by the roar of the water escaping from the lake, which rushed down a ravine, and, damming up the stream, destroyed the iron bridge, driving the heavy iron girders a considerable distance up stream. I proceeded at once to Government House, quarter-mile distance, which I found a complete ruin. I went on to the Secretariat Press and my own office, where I found a messenger buried in the *débris*, his head alone protruding. I saw to his rescue. The man had a marvellous escape, and has since recovered. At the Secretariat Press, where the chief disaster occurred, many willing hands were soon at work. While at my office I was informed of the collapse

of Mr. McCabe's bungalow, and that he was buried under the ruins. I went straight there. Unfortunately, the bad news proved to be only too true. I waited while the body was being recovered. I ordered two constables to endeavour to open communication with Sylhet. Returning by the telegraph office, to which I had already been, I found the officials still vainly endeavouring to connect with Gauhati and Sylhet. I then went to the bazaar and the police lines, and despatched two constables down the Gauhati road. The men had to reach Gauhati, 63 miles distant, on foot. Rain commenced falling at dusk, and continued all night until the following afternoon. I then had double guards placed over the treasury, where the boxes and almirahs were exposed, and over the jail, the walls of which were level with the ground. It was now nearly dark. Shortly after 10 p.m. I proceeded to visit the treasury guard, police lines, and jail, where the prisoners were spending the night in the open. While at the jail about midnight, an alarm of fire was raised from the main bazaar. I went across from the jail, and found a shop in the centre of the bazaar on fire. The iron roof had collapsed like every other one in the station, and the fire must have been smouldering for hours. I had a passage cleared on either side through the *débris* of the adjoining shops, to prevent the fire spreading, a very necessary precaution, as one of the shops contained a large quantity of kerosene oil. From the fallen roofs of the adjoining shops earth and water were thrown, and the fire was finally got under about 1.30 a.m., when the woodwork and contents of the burning shop had burnt themselves out. Had the fire spread as at one time seemed likely, it would have resulted in the destruction of all food supplies. I then revisited the treasury guard, and went on to the co-operative stores, on which I had placed a police guard to prevent looting, and returned finally to the Secretariat Press. At the Press I found the Gurkhas, who had been working all night, recovering the killed and wounded at the risk of their lives amid successive shocks, the worst of which occurred shortly after 1 a.m. The men were quite fagged out. It was now about 3 a.m. Day revealed the fact that Shillong was without a water-supply, and that it was cut off from communication with the outer world. Water from the pipes for drinking purposes was not to be expected, and could not be laid on for some days. But even the water in the numerous open channels throughout the station had disappeared. As regards communications, the telegraph officials, to whom I lent ponies, returned from the 61st mile, as they were unable to cross the swollen torrent. In the afternoon a second batch of messengers to Gauhati swam the river, assisted by ropes."

"The pressing questions were obviously supplies and communications, and last, but not least, sanitation. After visiting my own house about 5 a.m. in the morning of the 13th, in the vain endeavour to get some dry clothes, as I had been out all night in the rain, I proceeded to the bazaar to inquire into the

supply question. The dealers owned up to having 1,500 maunds of rice, 200 maunds of *ata*, and about 200 maunds of *dal*, sufficient for about a fortnight, though, for obvious reasons, the supply was no doubt understated. For the first three or four days there was a considerable scare, so much so that many persons laid in stock enough to last for a month. I accordingly found it necessary to arrange with a dealer, the only man who came forward, for the import of 5,000 maunds of rice by 1st July. The rest had formed a ring prepared to charge anything which panic-stricken people were willing to give. The rice-eating population of Shillong is largely composed of clerks and their families, so, in order to prevent extortion, while not interfering with legitimate free trade, I fixed the price at 8 rupees a maund, which gave the vendors ample profit on the stocks they had in hand. At the same time I informed the ring that I would seize their rice and have it sold by the police, if my orders were in any way infringed. I did not find it necessary to fix a narrow limit to the amount sold to individuals, as it was soon obvious by daily noting the sales that the supplies would last longer than the estimated fortnight, and the orders already issued had a most salutary effect. Fortunately, potatoes, which could not be exported owing to the stoppage of communications, were unusually cheap and plentiful. At the same time, until and for some time after it was known that the Gauhati road had been reopened to within 53 miles of Shillong, there was considerable anxiety as regards supplies."

You will observe that an Indian official does not hesitate to interfere with the freedom of trade when he thinks interference necessary. The fame of our Gurkha troops has spread far; on this, as on other occasions, they were our friends in the hour of need. Immediately after the earthquake they worked day and night in rescuing the unfortunate people entombed in the Secretariat Press. They assisted in building huts and improvising accommodation for the civil population. They even worked on the roads and bridges.

At 5 p.m. in Indian stations the European inhabitants are generally out of doors riding, driving, playing tennis—generally taking the air after their day's work. On Saturday afternoons they are out of office earlier than on other days. The Chief Commissioner and his wife were just stepping into their carriage at the front door of Government House to go for their evening drive, when the first shock was felt. The ponies bolted and carried the carriage clear of the falling building. Had the earthquake occurred while the officials and clerks were in their offices, or at night, or, indeed at any other time, the mortality must have been terrible. Poor Mr. McCabe was

suffering from neuralgia, was lying down perhaps asleep, when the catastrophe occurred. Some official papers were found with the body, so it is conjectured the poor man had been disposing of office work as he lay in bed. We may learn from poor Mr. McCabe's fate what would probably have happened had the earthquake occurred at night. The only other casualty among the European community was a retired officer of the Survey Department who was caught inside his house and was buried in its ruins.

MR. MCCABE.

Mr. McCabe was, at the time of his death, head of the police department in Assam, an important position, because in this frontier province, besides the ordinary military force there is a body of military police some 3,000 strong—a small brigade. In recording the death of this distinguished officer the Chief Commissioner wrote in the first "Gazette" published after the catastrophe on June 26th:—"His whole service had been passed in Assam, where he was mostly employed in frontier duties and had acquired an unrivalled reputation for courage, resource, forbearance, and temper in time of crisis and difficulty. He was as much esteemed in the plains districts of the province as he was respected and loved by the hill tribes among whom he lived so long. His death is an irreparable loss to the province and will be mourned by innumerable friends in every district of Assam." I may add to the Chief Commissioner's words that the mourning extended far beyond Assam.

Though they are not so generally out of doors at five p.m. as the Europeans the natives are at that time at least awake and moving, many of them actually outside their houses. It was the Mohammedan festival of the Maharram and in the plains districts, especially in the southern valley, the population of which is largely Mohammedan, many people were at the time of the earthquake celebrating the festival by processions and otherwise. In Shillong, among the native population there were only 29 deaths, 10 of which were caused by the fall of the Secretariat Press. The clerks and workmen in this office had not been dismissed at the usual hour, five p.m.

GAUHATI.

Gauhati is, as I have said, the chief town of the Northern valley. It lies 63 miles due north of Shillong on the Brahmaputra river, which here flows through some outlying spurs of the

central range which gives the river the appearance of a lake. The earthquake is stated to have reached this place at 5.15 p.m. local time. The sun was shining, the sky was a little gloomy, the weather was perfectly still. The shocks grew in intensity, houses and trees began to rock as if in a violent storm, and it was difficult to stand. The earthquake lasted about three minutes. The direction seemed to be from south-west to north-east. All buildings with masonry walls collapsed. Buildings supported by strong wooden or bamboo posts with lath and plaster walls escaped serious injury. Buildings with iron posts hardly suffered at all. The wards in the jail, which consist of an iron framework with lath and plaster walls, and corrugated iron roofs, supported some 6 feet from the ground on masonry pillars, were uninjured, though the high wall round the jail was completely demolished. The road along the river-bank subsided in several places. At several places springs of water with very fine sand the colour of Portland cement bubbled up, and the bubbling lasted for 24 hours. The Brahmaputra rose four feet, and, at any rate near the banks, flowed up stream. There were only five deaths in this town.

A friend sends the following description :—

"I had left my house after taking tea. I had driven 100 yards from my gate, when I thought I heard the drums of a procession (it was the feast of the Maharram) and sent my syce to the horse's head. The noise increased, and I then recognised the rumble of an earthquake. At that moment the shock began—three or four fairly strong ones. I scrambled out of my trap only to be thrown down on my hands and knees, and for nearly three minutes I was in that position, being on a sea of earth which heaved up and down and backwards and forwards. I could hear only the rumble and the swish of some small trees near me as they rocked violently to and fro—just the noise a boy makes when he shakes a small sapling violently. I got up as soon as the worst was over, and looked back at my house. It was invisible—a red cloud had taken its place. I ran back and found my wife and a lady who was staying with us on the grass 20 yards from the house. They got out of the house just before the heavy shocks came. All the other Europeans in the station were either out of their houses or got out of them in time. We all spent the night on board one of the mail steamers moored to the bank, but were turned out at 5 a.m. into pouring rain, as the steamer had to proceed on her voyage."

The experiences of a passenger on board a steamer moored at Gauhati are interesting. He writes :—

"We were anchored at the time. I was on the foredeck talking to the captain, when I suddenly heard a strange rumbling noise coming, as I thought, from the engine-room. Then it grew louder and louder; the captain then said 'it is an earthquake.' No sooner had he said this than I was thrown off my feet as the steamer seemed to be thrown up. I was obliged to cling to a pillar for support, as it was impossible to stand without assistance. I saw the large masonry landing-place, arches, roof, and walls, crumble to the ground like a pack of cards. All the buildings I could see fell to the ground with a crash. I saw the top of the temple on Peacock island fall into the river. Although we had three anchors down at the time the storm-wave was tossing us about. Even the next morning the river was still terribly rough."

SYLHET.

Sylhet is the chief town of the southern valley. It is only some 60 feet above the level of the sea. In the cold season the tide is noticeable within 30 miles of the town. It lies some 60 miles south-south-east from Shillong. The earthquake is stated to have occurred here at 5.16 p.m. local time. The duration was about one minute and three-quarters. During this time there were three distinct shocks, one slight preliminary one and two severe ones. Houses both brickbuilt and thatched were demolished.

The mortality in the town is represented to have been 55. Here as elsewhere the earthquake occurred at the most favourable time. The prisoners in the jail, some 500, were in the jail yards waiting to be locked up in the sleeping wards. Had the shock been a quarter of an hour later hundreds of them must have been killed; as it was, only ten lost their lives.

A native gentleman recorded his experiences as follows :—

"The first shock came from the north-west corner—more from the north than the west. I lingered in the verandah but as the plaster and bricks began to fall about my ears I came out reeling about. By this time the shock came with a deep low and suppressed rumbling sound, which passed from north-east to south-west. Everyone was thrown down now, and it struck me how it was that I was standing, though almost dancing about. I was facing west, but was looking at the betel trees, bamboos, and houses on the north. These were swaying to and fro at first north-north-west to south-south-east; afterwards west-north-west to east-south-east. It was then that the masonry house on the Mulvi hill came down with a crash, falling towards the north-west, and the dust rising that way also. Then other houses came down, sending the red dust towards the north, though the wind blew from west. Houses, huts, bamboos and other trees were swaying west-north-west to east-south-east. These appeared

as if on the ridges and valleys of big undulations. Immediately after the first shock there were loud and long cries of 'horibole,' 'Alla!' from thousands of throats, and the women called 'ulu, ulu.' During the continuance of the shocks these cries entirely died out, giving a most oppressive stillness for this part of the day. On the open ground everyone who was coming or going was thrown down. Some tried to get up, but came down more than once. Others tried to remain where they fell, but could not, and began to roll about until steadied by clutching the grass. Many sat up with knees and feet on the ground, and steadying themselves with the hands appeared like huge frogs."

In the river a big wave 10 or 11 feet high was formed and dashed against the north bank and overtopped the road. On the road this gentleman afterwards found coolies catching fish, from small fry to 3 to 4 lbs. in weight. This harvest of fish was reaped in many other places. The river Kosi, in Bengal, delivered up a large one. Very large-sized fish were found dead and dying on its banks.

The buildings at Sylhet did not come down in any particular direction; they fell all of a heap. In some cases direction was noticeable, but it varied in different buildings; walls of enclosures fell in all directions, those running north and south fell partly to the east and partly to the west, while those running east and west fell partly to the north and partly to the south. The upper half of a Hindu temple fell towards the south, landing on its apex, in which position it remained, looking like a wine glass broken off from its stalk. The top of the Inglis monument at Chhatak fell in one block to the south and a portion immediately below it fell to the east, while a third portion next below did not fall, but was twisted round at right angles to its base, which did not move. A peepul tree growing on the bank of the river Surma slipped into the river with the bank and travelled about 300 yards up stream against the current before it came to rest. This phenomenon, the water of rivers flowing up stream for a time, was noticed at Gauhati also. I have not found it mentioned in connection with other earthquakes. As rivers in alluvial deposits have a fall as low as 3 inches a mile, a small upheaval would serve to turn them back. Later on I shall notice a general upheaval of river beds. The native gentleman further remarks that many places which were flat before retained the undulated formations to which they were thrown by the earthquake.

This gentleman relates how he was riding at a canter three days after the main earth-

quake, when he was overtaken by a shock. The pony was thrown off its legs, fell, and broke its neck.

TURA.

The little hill-station of Tura lies at the extreme western end of the central range of hills, about 1,500 feet above the sea. The shock here began with a sharp vibration, increasing in about 20 seconds to a violent rocking and heaving motion of the earth, which lasted about three minutes; in about two minutes more it gradually subsided to a gentle, but distinct, tremor. Landslips occurred wherever the ground was steep and not formed of solid rock. Cracks in the ground opened out everywhere, chiefly along the upper edges of sloping ground, but also on the level crests of the spurs. Where the soil is sandy and fairly level, the ground looks as if a steam plough had passed over it, turning up the turf, and throwing the clods in every direction, some up hill and some down. In many cases the sods were turned completely over so that only the roots of the grass are visible. Large pieces of turf were found lying on the grass with no mark or sign to show the place from which they had been torn.

A stone in the parade ground, about 20 inches in diameter and 10 inches thick, partly embedded in the ground, was thrown to a distance of about three feet and turned upside down.

The offices and houses in the station consisted of a wooden framework, filled in with lath and plaster, with roofs of thatch or corrugated iron. Some had masonry plinths, others wooden floors raised from the ground. The masonry plinths crumbled away like sand, the stones rolling on all sides. Where the posts on which the houses lent were driven deep into the ground the damage was great though the posts did not actually fall down. Where the posts instead of being driven into the ground rested on stones flat with the earth, the houses withstood the shocks with comparative immunity.

A gentleman writes:—

"My wife shouted to the nurse, 'Earthquake,' and seized one child while the nurse seized the other. The nurse who was in front rushed down the front verandah steps in frantic excitement when the steps gaped open and her foot got into one of the fissures and she was tripped up. The roof then came down and the nurse's little charge was concealed under it, where it had sagged. The native house servant pluckily bore the weight of the whole roof section on

his back as it had slipped down and thus saved the child from being crushed beneath its weight."

In the Garo hills district, of which Tura is the head-quarters, numerous small lakes have been formed, $\frac{1}{4}$ to $1\frac{1}{2}$ miles in length and 10 to 20 feet deep. Saplings, 5 inches in diameter, have been snapped off some feet from the ground: such was the intensity of the shock.

EXPERIENCE OF CIVIL SURGEON OF GOALPARA.

The Civil Surgeon of the Goalpara district, which lies at the western or lower end of the northern or Brahmaputra valley, happened to be in camp at the time of the earthquake, and has written a very vivid account of his experiences:—

"I was in camp at Jemadarhat, on the trunk road, some ten miles east of Dhubri. The rest-house was burnt down some months ago, and my servants rigged up a small godown, about 16 feet by 8 feet, for me to stay in during the night.

"At 5 p.m. came this terrible earthquake. I invariably sit out an earthquake, as I have always thought the worst is over before one has time to get outside a house, but though I was safe enough in the light shanty I was in, I had to rise, as the shock seemed never-ending, and a roar of water flowing near, and the hum of voices, compelled my getting up. The villagers were panic-stricken and fleeing from their houses to the trunk road. The ground I at once saw was everywhere cracked up, sunk, &c. Behind the old rest-house is the termination of a very long lagoon. It was a wonderful sight, this lagoon. The water rose steadily in it, and in two minutes must have risen at least 12 feet and then overflowed, and with this overflow the whole country, as far as the eye could see on each side of the trunk road, was one sheet of water; the fact being that, from all the innumerable cracks water had gone on spouting, and that, coincidentally with the overflow of this lagoon, the water level had risen to the same height all over the surrounding country.

"In addition to the cracks from which the water welled up carrying the sand with it, innumerable jets of water, like fountains playing, spouted up to heights varying from 18 inches to quite $3\frac{1}{2}$ or 4 feet. Wherever this had occurred, the land was afterwards seen to occupy a sandy circle with a depression in its centre. These circles ranged from 2 to 6 or 8 feet in diameter, and were to be seen all over the country. In some places several were quite close together; in others they were at a distance of several yards apart. They had the appearance of small craters. I have heard it said that the water from the cracks and these so-called fountains was warm, almost hot, but this must be due to someone's imagination. I had to wade through a good deal of water whilst the water level was rising, and had the temperature of the water

been abnormal, it must have made itself felt to me. It must not be overlooked that the country had been waterlogged days before the earthquake came, and that it must have been this water which was driven up with the subsidence of the land, as I believe the quake was due to a subsidence.

"In front of the Jemadarhat rest-house the Garo hills are within five miles, and behind it is the Brahmaputra, at a distance of not more than two miles. The trunk road remained above water, but in certain portions where it had subsided from one to two feet, the water flowed across it, and at these places, where the panic-stricken villagers tried to run towards the direction of Lakhipur, which is 12 miles off in the Gauhati direction. the poor creatures got more alarmed than ever, for they found themselves sprawling about in the water, unable to realise what had barred their progress, and not knowing if they were going to get out of it again. At all these gaps or places where the earth had subsided, or where fissures and cracks had formed, the rush of water from them all carried with it an immense quantity of sand, and this was what barred the progress of these panic-stricken villagers. This sand had a particularly quick-feel about it, but fortunately, as a rule, was not deep on that portion of the road that had subsided near the rest-house.

"The main shock seemed to me to have lasted nearly six minutes, but perhaps in this I am wrong, and perhaps I may have missed a cessation and taken two or more shocks as one, for certainly I noticed no cessation. It seemed as though death from drowning must have been the end of every one near me. Although the shocks went on being repeated incessantly at intervals of a few minutes, the rise in the water ceased after half an hour, and then the idea present to one's eye was that the country on either side of the road was nothing more than innumerable sand-churs of different sizes, such as are met with in the Brahmaputra. This meant, of course, that crops were considerably covered by this sand. Most of the excavations made by the earth-cutters annually on each side of the trunk road to enable them to throw fresh earth on to it have been filled in by this sand.

"All the panic subsided by about 9 o'clock; the hut I was originally in was now under water, and I could not get back to it. Many of the villagers' houses and those of the shopkeepers had sunk a good deal, whilst others filled with two or more feet of sand through the doorways. My horse broke away towards the end of the first shock, and made for home, the groom after her as hard as he could go, but on reaching a good strong wooden bridge, she was stopped by the bridge subsiding on the Dhubri side. Cattle seemed to find great trouble in extricating themselves from the sand and water, which but a few minutes before was their grazing ground. Villages were wholly vacated and refuge taken wherever high land was available. Almost everything is said to have its ludicrous side, and in the midst of confusion and

the marked panic of the villagers, it was amusing to find my cook busy at work preparing dinner within half an hour of the occurrence. There he was, as though nothing had occurred, on the plinth of a burnt-down hut only just above water, and surrounded on all sides by it. I was very grateful to him later on for not having parted with his wits.

"As the rush of water ceased and order was to some small extent renewed, those who were able to do so scrambled to their huts, and brought out boxes and bedding, &c., &c., and, with their belongings, encamped on the road for the night. At about 10 it struck me I might have a roof over my head if I got near the ferryghât, as there was a tumble-down serai there. I had gone half a mile when two men assured me it was impossible for me to progress, owing to a gap of several feet in the road through which water flowed, and across which they had just swum. On hearing this, I returned, and with my bed on the road, attempted to get some rest. This was impossible, with the continuous and oft-repeated seismic shocks at short intervals, which, whenever the least bit strong, were followed by the wail of human voices. Cattle, goats, and dogs formed a goodly addition to those resting on the road for the night. At 2 a.m. a sharp drizzle came down, and with my umbrella over my face and a rug over my body, I weathered it out till 3 a.m., when my rug had got wet through. Close by was the rest-house well. I now transferred my head-quarters to it by wading across 2 feet of water for about 15 yards, and then spread a dryish rug on the masonry platform of this well. The well and its platform had both been badly cracked at 5 p.m., and the water had risen to within 18 inches of the surface. It had a thatched covering over it, and this sheltered me during two hours of heavy rain.

"At 5 a.m. I rose finally, having had a fair night's rest under most extraordinary circumstances. Having had some breakfast at six, I started to walk back to the ghât, having learnt that the road was impassable towards Lakhipur. As the road was heavy, and my groom had developed strong fever, I left him the trap to drive in slowly. The whole trunk road from Jemadarhat to the river, which I had seen, had cracks running along it, which were in some instances 100 feet long; in others the earth had subsided for a similar distance, and then, again, traverse cracks, depressions, &c., existed all along the road, at distances of a few feet for miles; the same thing seemed to have occurred off the road side. The villagers stated that they had lost the grain they had stored in their houses."

CONDUCT OF NATIVE SERVANTS.

The Civil Surgeon's reference to his servants' conduct on this occasion reminds me of Lord Roberts's bearer, who in the thickest of one of his many fights nudged his master and informed him his bath was ready. Indeed, the conduct of native servants in this hour of

trial was exemplary. A correspondent from Shillong writes:—

"Never were masters better served than were we. They slaved. Like ourselves, they were homeless, clothesless, wet, and comfortless; but never a grumble was heard, and their first thought was ever for us. Nothing came amiss to them, and if we suffered discomforts, it was in spite of their untiring devotion and energy. And as for their honesty, it was prodigious. We were absolutely in their hands. The genuine pleasure with which they unearthed from the *débris* and brought to one valuables they could easily have misappropriated was something to be remembered."

CONDUCT OF NATIVE POPULATION.

Though there was some panic at first, the native population on the whole behaved exceedingly well. The Garos of the hills left their fields and retired into their houses to await further catastrophes. The Garo belief is that the world is a square flat body, hung up by a string at each corner. There is a squirrel always trying to gnaw these strings, but to prevent it, a demon was appointed. This demon, however, neglected his duty, and in order that his attention might not in the future be diverted from his work, he was struck blind. Now that he can't see, the squirrel of course has the best of it, and it is feared that when one or two of the strings are gnawed, the earth will be turned upside down. Another story is that Her Most Gracious Majesty, not content with the last earthquake, has ordered another and more vigorous one to be followed by a cyclone. That it is in the power of the *Maharani* to do this is never doubted. One man asked for a *parwana* to forbid the hill behind his house from slipping down on to him. Had the houses of the European officials in Tura not been wrecked, the Garos would have made up their minds without doubt that the recent catastrophe was the work of the *Sahibs*, and excited by the wild stories in common circulation, they might have given some trouble.

Among the more civilised people of the southern valley the immediate moral effect was that everybody stayed at home. The population at large thought that the end of the world had come. There was for a few days a complete stoppage of business. In another district a rumour was spread, apparently by some priests, that a far more terrible earthquake would occur on July 3rd, that the earth would collapse and disappear under water. The people sat outside their houses all night, pre-

pared rafts to float them in case the deluge should take place. In one station where all the public buildings had been destroyed, the local Court of Small Causes was at once established in a shed at the hospital, ordinarily used for the accommodation of cholera patients. This, it is officially reported, gives some idea of the readiness of the people to adapt themselves to the situation.

FURTHER TROUBLES.

Besides being homeless, our countrymen in Assam had much else to suffer. After the great shock, the earth tremor was continuous for several days, and definite shocks were incessant for two or three days. At Shillong itself, it is estimated there were 200 shocks a day for the first two or three days after the catastrophe, and that these gradually diminished to 20 and 30 shocks a day up to the middle of July. Since July there have been 257 shocks felt, and of these 24 were severe. Some of these shocks sufficed to displace one or more of the cylinders of the seismometer I have described, which is not sensitive to slight shocks. A friend, writing from Gauhati, on September 17th, says:—"This is the first day without a shock since the memorable 12th June." At Goalpara, below Gauhati in the northern valley, 300 quakes were noted between July 10th and August 9th. Up to August 1st, these came from the south-east, after that from the north-west, which is not easy to account for. Shocks were so frequent between June 12th and July 10th, that no one had time to note them. So lately as January 9th, there was a severe shock at Shillong. I am speaking now of shocks of sufficient intensity to be recorded without the aid of instruments.

Great earthquakes are usually followed by a series of smaller ones. It is said that during the six months succeeding the Japan earthquake of 1891, 2,500 shocks were recorded—200 and 300 shocks within a few days of the main one are a common experience. The shocks decrease happily both in intensity and in frequency as time goes on. Of course, any large earthquake may originate others at a distance; the shaking may cause ground in a critical state to give way, and so on; or the cause of the main earthquake may continue in operation; for instance, one large fissure may be followed by smaller fissures in the same locality.

The learned Professor Omori holds that after-shocks are necessary in the natural course

of things, as by their means the disturbed earth crust about the origin gradually settles into its final stable position. Each after-shock means the removal of one residual weak point near the origin. He also propounds the comforting theory that great earthquakes are not repeated from the same centre. A great shock implies the removal of a great subterranean point of weakness. It is highly improbable that another point of weakness comparable to it in magnitude is still existing in its vicinity.

Not only were people kept in a constant state of alarm by these incessant quakes. Both at Shillong and Gauhati, there was complete dislocation of the station water-supply; the drainage also suffered. At both these stations cholera broke out among the natives. At Shillong there was almost an epidemic of enteric fever among the Europeans. Generally the public health suffered considerably.

Yet in the face of this constant quaking and other troubles we find that cricket and polo were again in full swing before the end of July, which, I think, is a remarkable instance of recuperative power.

MESSAGE FROM THE QUEEN.

On Sunday, June 20th (the Sunday before our Jubilee procession), a Jubilee thanksgiving service was held at Shillong, in the shed on the cricket-ground, which had been such a welcome protection on the night of the earthquake. After the service, a kind message of inquiry from her Majesty the Queen was read out, assuring all her subjects—native and European—of her sympathy in their affliction. You will understand how such a message would lighten the feeling of isolation and desolation which at first oppressed the unfortunate people. The children appear to have suffered very little. They soon got accustomed to the comfortless open air existence which succeeded the earthquake, and rather enjoyed it.

BEHAVIOUR OF ANIMALS.

I have not found many references to the behaviour of animals. At Sylhet, the cattle, ponies, and goats, which were grazing in the open, stood still with distended legs facing towards the direction of the earthquake, head and ears up. When four-footed animals had not time to arrange themselves in this way they were rolled over. A very young colt, which was grazing with its dam, tried to scamper off when the rumbling was heard, but was rolled over. It tried to get up several times, but could

not. The kites soared about. An observer noticed the large bats, which we call flying foxes, flying and squeaking piteously round the bamboo clumps, from branches of which they had been hanging. Elephants generally just sat down, but in some cases they were caught and rolled over. The crows, who are always with us in India and give us notice of approaching storms, were much disturbed immediately before the shock, flying about and cawing wildly.

DAMAGE TO ROADS AND RAILWAYS.

I have described how the roads leading to Shillong were affected, and how that station was cut off from the rest of the world for days. Similar damage was done to roads in other parts of the province near the seismic centre. The railways also suffered considerably. Quite near the seismic centre, at the foot of the central range south from Shillong and north-west from Sylhet, was a small narrow-gauge line. At places on this line the rails have been pushed up to a height of $2\frac{1}{2}$ feet. At other places the line has been shifted to the east side of the embankment. Curiously, two large iron bridges have escaped. Another short line in the northern valley, leading from Gauhati to nowhere, which has hitherto been worked at a loss, has been so injured that it cannot be reopened till the end of this cold season. A line has lately been constructed along the south of the southern valley. Though some distance from the seismic centre, this line suffered a good deal. Where it crosses a swamp, the embankment has spread itself out over the swamp, and the rails remain suspended in mid-air. Generally, the damage was greatest in soft ground. One train was overturned, another was derailed and stuck. The Northern Bengal Railway, which connects Calcutta with Darjeeling, was much damaged by fissures and the sinking of embankments. In many cases, the rails were twisted out of place, and assumed a serpentine course.

TEA GARDENS.

The most important industry in Assam after ordinary agriculture is that of tea; and when the news of the earthquake first reached England, grave fears were entertained for the tea gardens. Fortunately they lie, for the most part, outside the area of greatest disturbance. Except in the immediate neighbourhood of Gauhati and Sylhet, the damage was not such as to stop manufacture. The

buildings consist generally of iron frames supporting corrugated iron roofs, the walls being also of corrugated iron or lath and plaster. Masonry buildings, where they existed, suffered considerably.

EFFECTS IN BENGAL.

The earthquake was felt in varying degrees of intensity throughout the neighbouring province of Bengal, but only the districts adjoining Assam, on the west suffered very severely. These districts are alluvial and suffered in the same manner as the alluvial parts of Assam. The towns of Runjpur and Mymensingh, lying west and south from the western end of the central Assam range, were destroyed. At Cooch Behar, north of Runjpur, the Maharajah had a narrow escape. Noticeable features were the opening of long cracks and fissures in the ground and the formation in places of more or less circular holes, through which water and sand were ejected. A considerable area has been strewn with sand. Sand was forced up in a large proportion of the wells, and rendered them dry and otherwise unfit for use. Tanks have had their bottoms raised by the upheaval of the soil. The largest fissures are stated to have attained a length of one mile, and in some cases a depth of 30 feet. In many cases houses have been half buried. Many small river channels have been entirely blocked by the upheaval of their beds and their becoming choked with sand. In this way the surface drainage has been changed in places. Several places which were not fordable before the earthquake and could be crossed only by ferry have become fordable. The bed of one river has risen about 10 to 15 feet for a distance of some 20 miles, and as a consequence, the drainage has passed over the country, flooding a number of villages. While masonry buildings have all been destroyed, native houses of mud, wood, matting, and thatch, have escaped with comparative immunity.

FISSURES.

I have referred more than once to fissures caused by the earthquake. These fissures play a very important part, especially in the alluvial portion of the province. You are, probably, all more or less familiar with the formation of alluvial tracts. As a river approaches the sea level, its fall becomes much less. Hitherto, it has been destructive; it now begins to construct. It is split up into branches which wind to and fro through the flat alluvial land, often coalescing, and thus enclosing insular

spaces of all dimensions. The feeble current, no longer able to bear along all its weight of sediment, allows much of it to sink to the bottom, and to gather over the tracts which are from time to time submerged. The sediment, especially the coarser and more sandy matter, sinks quickly when water becomes still, so the banks of the rivers and channels rise quickly compared with the interior of the insular spaces, which they encircle. These insular spaces thus become shallow basins. These basins become filled as the rivers rise, partly by leakage, and partly by drainage. When the river overtops its banks it meets this body of still water, is reduced to stillness itself, and deposits its silt. Thus the slope in these alluvial tracts is from, not to the rivers. The rivers gradually embank themselves, then the beds begin to rise. When the bed rises to the level of the adjacent basins, the river often breaks through into one of them and forms a new channel across it, the banks of which gradually rise as the original banks did.* You must imagine the whole of the alluvial portion of the northern and southern valleys of Assam, and the delta of the Ganges and Brahmaputra rivers in Bengal as formed in this way; a series of high banks either of actually existing rivers, or of old exhausted river channels. In the rainy season, when all the intervening spaces or basins are filled with water, these banks are the only land above water. They are, therefore, the natural site of towns and villages. You must imagine almost the whole population, in the southern valley a very thick population, congregated in these high banks, which are, of course, very unstable. A large part of the southern valley is true delta—much of the northern valley, thought not true delta, is alluvial. Even where the land is not subject to annual flood, and alluvial formation is no longer in progress, the population is attracted to the river banks, because the rivers supply good waters, and are easy means of communication. You will, therefore, readily understand that the collapse of the banks of the rivers would entail great losses on the people.

In the western end of the southern valley all the villages were cracked more or less, the width of some cracks being 15 or 16 feet. All this part of the country lies so low that in the cold season, when the rivers are low and the country dry, the tide is felt. Where the high banks of rivers are not available for sites, the

villages are built on artificial mounds, which are as susceptible to earthquakes as the embankments on roads and railways. Generally as I have said, the bamboo and mat huts in which the natives lived fared pretty well wherever the ground remained unbroken, but they succumbed to fissures and unequal sinking of the ground. At the station of Nowgong in the northern valley, on a branch of the Brahmaputra, the damage done was caused not so much from the pull of the earthquake or by the subsidence of the ground, as by huge rents several feet wide, parallel to the river. In the southern valley at one place 41 persons were collected, celebrating the Maharram festival on the river bank; they subsided into the river with the bank, and were drowned. In another place in the same valley, a small bazaar or market on the bank of the river sank into it, causing the death of 29 persons.

There are several apparently authenticated instances of persons having been swallowed up in these fissures. An old woman was sitting in the yard of a Hindu religious house, when the ground opened exactly beneath her and she disappeared. In another case, a man and his wife were standing on the river bank when the earthquake took place, and a fissure opened under the woman, who fell into it. The husband caught hold of her hair to save her, but, finding his own position insecure, let go his hold, and the woman fell into the aperture. In neither case were the bodies recovered.

The formation of fissures may be explained as follows:—As long as the wave of elastic compression, which I have described above, is propagated through a continuous medium, each particle has a limit to its extent of motion dependent on the nature of the medium. When the medium is not continuous, but suddenly terminates with a cliff or scarp, the particles adjacent to this cliff or scarp having no resistance to their forward movement, are shot forward. The well-known illustration of a row of boys, each one standing with his arms stretched out, and his hands resting on the shoulders of the boy in front of him, will occur to you. A push being given to the boy at the back of the row, the effect is to transmit a push through the whole line to the boy in front, who, being unsupported, flies forward. When the rivers are in full flood, the water would to some extent support the banks.* Landslips on the sides of the hills are caused in a similar way. These have been specially fatal on the southern face of the central hill

* Fergusson's "Ganges Delta," "Journal of Geological Society of London," vol. 19.

* "Earthquakes" (Milne), p. 136.

tract. To any one looking up from the southern valley, the precipitous sides of the hills appear to have been scarred, as far as the eye can see, by numerous and extensive landslips, resembling glaciers running down into the valleys. The village of Laitiam was situated in a deep valley, running west to east, with cliffs some 2,500 feet high on the northern, western, and southern sides. Over the northern cliff broke a famous waterfall some 1,600 feet high, which always reminded me of the Yosemite Valley in California—which many of you have, no doubt, visited. Above the fall, and surmounting the cliff, were some grassy hillocks composed of red clay. These were shot over the brow of the cliff, and overwhelmed the village below, causing 86 deaths.

One of the prettiest and most flourishing villages in the central hill tract of Assam was Cheyla. It has been described as one of the most beautiful villages in the world. It was built up the side of a steep hill with a gradient of about 1 in 3 from the bank of the river. The houses or huts rising one above the other were lightly built of wood and thatch. A large part of this village slipped down the hill into the river below, completely filling up the beautiful fishing pool. But only 117 out of a population of 4,000 were killed. At first sight it seems a marvel how any could have escaped. Doubtless the people owe their preservation to their style of building, their architecture or want of architecture. In another village 59 persons were killed by land-slipping. Altogether, some 900 persons perished in that part of the central tract which lies between Shillong and the southern valley. In this tract is situated Cherrapunjee, famous for its rainfall of 300 to 600 inches per annum. This ancient settlement was entirely destroyed. In the coal mines at this place—galleries driven from the side of the hill, the roofs of which were not properly supported—17 persons were killed.

GEYSERS.

Frequent reference has been made to geysers, the spouting up of sand and water, often accompanied by a sulphurous smell, and to the falling in of wells and tanks.

At Nowgong, in the northern valley, in every small area a jet of water and sand was thrown several feet into the air, and added to the terror of the inhabitants. This ejection was made with such force that the covers of wells embedded into the mortar were hurled aside and the wells were filled in with many feet of sand. A tank 14 feet deep is now dry, and

has a layer of fine sand within a foot of its top. In this way a great part of the station is covered with sand.

At a place in the same valley, below Gauhati, the action of the earthquake in the bazaar was most extraordinary. Several houses subsided 6 feet, and to that height were engulfed in fœtid smelling water. Other buildings were thrown down and embedded in 6 feet of sand. A well was altogether filled up with sand, and a portion of the wooden cover was hurled 30 feet distant, where it lies half buried. Huge fissures running east and west are to be seen everywhere.

At the western foot of the central range deep cracks and crater-like pits appeared in the ground; one of the cracks is as much as a mile long, 2 or 3 feet wide, and 16 feet deep. The pits average about 6 feet in diameter, though one is said to be as much as 40 feet across. Through these fissures jets of sand and water were thrown up to a height of 6 or 7 feet, in a few cases accompanied by pieces of coal, peat, resin, masses of semi-petrified timber, and a black earth hitherto unknown in those localities.

These phenomena were a very marked feature of the 1869 earthquake, and were carefully investigated by the late Dr. Oldham, of the Geological Survey. They are accounted for as follows:—*

Water, sand, &c., are forced up from beds of ooze or water-bearing strata through any aperture communicating with the surface. Such beds of ooze exist generally in alluvial formations, especially when such formations are still subject to annual flood. A horizontal wave passing through such a bed tends to pack up the water and soft material during the forward motion. A vertical wave acting through a water-bearing bed upon a superincumbent layer of impervious material (usually clay) compresses the former upon the latter, which by its inertia remains for a moment unmoved. In either case, the water-bearing stratum receives an enormous squeeze, and the water or mud starts up through any crevice which may be formed leading to the surface. A wave impinging on such a stratum at an angle would combine the two effects—horizontal and vertical—with a similar result.

UPHEAVAL OF RIVER BEDS.

Another curious and disastrous effect of the earthquake, especially in the lower or western extremities of the two valleys, remains to be

* "Cachar Earthquake, 1869," "Memoirs of Geological Survey," vol. 19.

noticed. Though the rainfall has not been abnormal, and though, according to the gauges maintained at Sylhet and Gauhati, the rivers have not been abnormally high, the floods have been unprecedented. For instance, at an important station towards the western end of the northern valley, the flood has been 6 feet above any previous record. It reached its highest recorded level the day after the earthquake. The public buildings were all up to their eaves in water, but in the river, which flows past the station, there was only 3 feet, where there should have been 20 feet, of water. It has been thought that the general level of the country has subsided. There have, of course, been many instances of such subsidences in connection with earthquakes. In the Mississippi, in the earthquake of 1811-12, a tract 80 miles long and 30 miles broad sank many feet, and lakes 20 miles in extent were formed in an hour. In the Chittagong earthquake of 1762 60 square miles of the coast are stated to have suddenly and permanently subsided. A correspondent accustomed to navigate the Brahmaputra river, writes :—

“There cannot be any doubt that the whole country below Gauhati has sunk; my brother skippers and the native pilots all agree in this opinion. Places where we used to see the banks high and well out of water in the highest floods are now entirely covered. I should think the country has sunk from 3 to 6 feet.”

But a general subsidence will not account for the facts. Measurement shows that the rivers in many places have less water than they had before the earthquake. In many cases the piers of bridges have been forced bodily upwards. This rise in the river beds may be due to the accumulation of silt caused by the collapse of the banks above alluded to. In the southern valley the rivers are stated to have widened. The collapse of the banks has, no doubt, continued as the level of the rivers has fallen and the support of the water has been removed.

River banks are always falling in. In alluvial formations the rivers follow a meandering course, describing curves which vary with size of the river. The rivers swing from side to side, where the current beats on the banks in the course of this swing enormous erosion takes place. This erosion sometimes extends to the breaking through of the isthmus separating two neighbouring curves. Considerable tracts are thus swept away, especially when the river is subsiding after the flood season. Thus the rivers normally carry away an enormous amount of silt, and it is probable that

if it is only silt they have to move, they will be able in time to perform the abnormal task which the earthquake has set them. But meantime the process which I have described by which alluvial tracts are built up is accelerated, and the rivers may break through their banks into the basins on either side, and great and injurious changes in their courses may result. It may be that this filling up of drainage channels is due to the same cause as the filling up of wells or tanks, noticed above. The river beds being softer than the material on either side, may have been squeezed up. If this has happened, the obstruction is likely to be more permanent than if it were due only to an accumulation of *débris* of fallen banks. So important does this matter appear to the Chief Commissioner that he has appointed a special officer to make inquiry into the altered drainage of the country, the physical phenomena of beds of rivers rising and banks of rivers sinking, and also into the allegation that large tracts of the country have subsided.

BUILDINGS.

In my remarks on the destruction wrought by this earthquake in the Assam stations, I have tried to bring out the different resistance of different kinds of buildings. Generally the bamboo and mat-hut of the native—not at all an insanitary abode in a very hot climate, is exceedingly well adapted to an earthquake country. That in all Assam only some 1,500 persons perished in this earthquake is a proof of this. Very few of the inhabitants could have survived had such an earthquake occurred in London or in any Continental city. Houses made of wooden frames filled in with lath and plaster fared pretty well. All masonry buildings succumbed. It will be understood, of course, that only ground floor buildings are in question. The ordinary bamboo and mat-hut is not sufficiently substantial for public offices. Masonry buildings at once collapse in a big earthquake, so for larger buildings we must have recourse to the frame houses. But among frame houses there is a very broad distinction. I would refer you to the instance I have given of some frame houses at the station of Tura, the posts of which were not imbedded in the ground. Earthquake experience has taught the Japanese this very lesson. Their houses consist of a light framework of 4 to 3-inch scantling, built together without struts or ties, all the timbers crossing each other at right angles. The spaces are often filled in with moveable

shutters; often with lath and plaster. The point I wish to insist on is that the uprights of the frames are not imbedded in the ground, but rest, if it can be called resting, on balls of stone or metal. An ordinary foundation for a post is a ball resting on three balls; often, however, the construction stands on the top of a row of boulders or of square stones. The point is to allow the building to move apart from the ground on which it stands, to place it upon a loose foundation, so that little momentum may enter it at its base. Chimneys are a great difficulty. They must generally be of masonry; masonry chimneys attached to wooden houses have a different period of vibration, and are very liable to fall. They should be allowed to pass freely through the roofs without coming in contact with any of the main timbers.

But where we avoid danger from earthquakes to a great extent, we incur perhaps a greater danger from fire. In India I have seen thousands of native huts of bamboo and mat and thatch consumed in a few minutes. In Japan tens of thousands of more or less earthquake-proof buildings are often destroyed in a single fire. Then earthquakes make fires, the buildings are easily inflammable by upsetting lamps, stoves, &c. Perhaps an iron framework filled in with some non-inflammable substance and resting on a loose foundation might answer the purpose. Boards, and even lath and plaster, can be rendered more or less non-inflammable by special preparations.

EXTENSION OF EARTHQUAKE.

This earthquake was felt over a very large area. By *felt*, I mean that people were sensible of it without reference to instruments. It extended into Burmah on the east, in spite of the intervening mountain ranges. On the south it was felt at Masulipatam, in Madras, and in Central India. Its western boundary is a line drawn from Simla, through Panipat, Ajmir and Mount Abu, and Ahmedabad, in the Bombay Presidency, that is, it was felt over a large part of Rajpootana. On the north it pierced the great range of the Himalayas, and reached Llassa, which is some 300 miles due north of Gauhati. At Guatong, our frontier fort on the road from Darjeeling to Llassa, it overthrew some chimneys. It was also felt at Khatmandu, the capital of Nepal. It covered an area over 1,500 miles long by 1,000 miles wide. The area of destruction was, of course, very much less. The waves grow weaker the further they go. From Jorhat, in the Assam

valley on the east to Monghyr on the west, and from the latitude of Darjeeling in the north, to that of Calcutta in the south the shock was more or less destructive—say 600 miles by 300. This is a very large area of destruction. The area over which the earthquake was felt is not unprecedentedly large. The Lisbon earthquake of 1755 was sensible over an area 3,500 miles long by 2,700 miles wide. And perhaps in the Lisbon and other earthquakes destructive effects have been observed over as large an area. But this earthquake is distinguished for the large area over which it attained a very high degree of destructive power. The violence of the shock, exceptional though it was, was at no place unprecedented; but over an area more than 200 miles long and not less than 100 miles broad, it was everywhere sufficient to wreck the most solidly constructed buildings. Seldom, if ever, has the meioseismic area—that is, the area of greatest disturbance—extended so far from the centre.

The delicate instruments now in use for recording earthquakes enable us to record such movements over very large areas. The great Gifu earthquake of 1891, in Japan, was recorded at Berlin and other places in Europe. The present earthquake disturbed the instrument at Bombay six minutes later than the shock was felt at Calcutta, which gives a velocity of three miles per second. It was recorded at Edinburgh, in the Isle of Wight, at Grenoble in Spain, at Rome, and at Batavia in the Malay Archipelago, and no doubt at many other places of which I have no information.

SEISMOLOGICAL RESULTS.

I am afraid the earthquake in Assam, so far as observations have been recorded, throws little light on seismological questions. We know that the earth is gradually contracting, that during the process masses of sedimentary strata many thousands of feet in thickness have been crumbled and crushed, that the crumbling has often been accompanied by such an amount of heat and evolution of chemical action as to produce a movement and re-arrangement of the elements of the rocks, this change actually advancing to the point of actual fissure. A great authority on earthquakes* has observed:—

“Contraction is constantly supplying a store of energy to be expended in crushing parts of the crust. But the crushing does not take place with uniformity. It necessarily acts *per saltum* after accumulated

* Mr. R. Mallet.

pressure has reached the necessary amount at a given point where some of the pressed mass, unequally pressed as we must assume it, gives way."

We know that somewhere under the central range of Assam—probably south-west from Shillong and north-west from Sylhet, probably not more than 20 miles from the surface—something happened which sent waves of elastic compression and distortion through the earth in all directions. The crushing and consequent heat caused by the gradual contraction of the earth may have caused water or oil to flash into steam, or steam may have suddenly condensed, or a volcanic surface may have exploded, or the roof of a subterranean cavity may have fallen in, or simply a stratum of subterranean rock subjected to long and intense steam may have snapped—given the pressure and the heat, we may imagine their acting in many ways; how they actually acted in this case I am afraid we shall never know.

My friend, Mr. R. D. Oldham, of the Geological Survey of India, who is an expert seismologist, has been employed during the last cold season in the investigation of this earthquake. By the kind permission of the head of the department, I am able to give you the first fruits of this investigation in the following note, which Mr. Oldham has sent me :—

"At first, there was a natural tendency to associate the earthquake with the great uniclinal flexure which skirts the southern edge of the Assam range. This was believed to be a region of tectonic movement, while the plateau to the north was regarded as a stable region.

"The existence of the depression of the Brahmaputra valley shows that this region has, in geological recent times, been subject to extensive changes of level, but the tendency to regard its southern edge as the principal zone of movement, in view of the geological structure and orographical relief of the region, probably represents the truth. From this, it was a natural step to conclude that what had been a zone of greatest movement in recent times was also the zone along which the focus of the earthquake must be looked for.

"At a very early stage in the investigation of the earthquake, this conclusion became questionable. It was found that if the centre was placed anywhere along the southern edge of the hills, there was a most unaccountably rapid falling off in intensity of the disturbance in a southerly, as opposed to a northerly, direction. Further, as soon as it was possible to arrange for some sort of a record of the after shocks, it was found that at stations along the northern edge of the hills they were extremely

abundant, so much so, that in preparing a list of the shocks I found it necessary to exclude the returns from Goalpara and all places south of the Brahmaputra in that district, as well as those from Shillong and Tura. All this region was subject to a number of small shocks which did not spread beyond it, and which seemed to be for the most part very local in their extent, even within the region lying between the three stations mentioned.

"From these facts, the supposition that the centre of the earthquake lay along the southern edge of the hills was discredited, and we had to look for it further north, but as the scanty knowledge of the geology of the northern part of these hills gave no indication of any leading tectonic feature, there was nothing to guide us to a conjecture as to the exact position, and I was deputed to examine the Khas and Garo hills during the working season of 1897-98, with a view to the filling in of this blank. In spite of the limited time, and the forest-clad nature of the country, which practically forbids any deviation from the beaten tracks, some important results have been obtained.

"In the eastern part of the Garo hills, and about the centre of the range, there are several pools which have been formed by a reversal of the slope of the stream beds. They vary in size, the largest being about $1\frac{1}{2}$ miles long and 18 feet deep, the others smaller. So far as I could discover none of these owed their origin to a fault appearing as such at the surface; the stream bed has been elevated or depressed in a gentle roll, and as the streams flow in rock beds this must be due to a deformation of the surface caused by a general compression of the hills. Towards the northern edge of the hills I found some faults which appeared as such at the surface; omitting the smaller ones, to which some doubt attaches, there are two principal ones. One at Samin can be traced for about $2\frac{1}{4}$ miles with a general direction of N.W. by W. and a maximum throw of 9 feet at the surface. The other in the Chedran valley has been traced for 12 miles before it becomes lost under the alluvium of the Brahmaputra valley at Jhira Hat. The throw varies largely, and will fall from 20 feet to nothing within a few hundred yards; the maximum actually measured was 32 feet.

"This fault in itself would be sufficient to account for an earthquake of the first magnitude, but it is only a small part of the cause of that of 12th June, 1897. There are the other disturbances of the surface to be considered, and in assigning a cause to the earthquake we must either regard each displacement as the sign of a separate form, and the earthquake itself as a compound one, consisting of a number of earthquakes which all occurred at once; or we may regard these surface displacements as themselves only secondary and indicative of a more general and simple disturbance.

"There is one point in which all these displacements resemble each other, and that is in indicating a horizontal compression in a north and south direction. The varying throw of the faults, as well as the rolls by

which the more southern pools have been formed, alike show that any two points lying respectively north and south of the disturbed areas are now closer together than they were before the earthquake.

"There is one, and so far as I can see, only one supposition which would explain all the facts, and that is the existence, or the creation, of a nearly horizontal fracture or *thrustplane*, along which the upper part of the earth's crust was pushed over the lower. This plane would nowhere come to the surface, and the movement of the upper layer against the undisturbed crust beyond the limits of the fracture would give rise to just that compression which would account for the conspicuous displacements of surface tracts seen in the eastern part of the Garo hills district, and less conspicuously to the east and the west of that district.

"In this conclusion we find an easy explanation of the area over which the shock had a maximum of destructive energy, without postulating an improbable depth for the focus. There is no necessity or reason to suppose that the thrustplane lies at any great depth from the surface, and it is possible that five miles may represent a maximum rather than a minimum value, but what the focus loses in depth it gains in area.

"It is certainly not at present, if it ever will be, possible to define the limits of the fracture. In an easterly direction there is good reason to suppose that it extended to, but probably not beyond, the meridian of Shillong. To the west it probably extends under the alluvium of Northern Bengal, perhaps as far as E. Long. 89° , or a distance of about 180 miles. The breadth from north to south is 35 miles within the Garo hills, in the eastern part of the district, and to the north it extends under the alluvium of the Assam Valley, possibly for as far again. These dimensions—180 miles by 70 miles—must be taken as extreme limits. There is at present no reason to suppose that they were exceeded, but there is no certainty that they were reached. It seems certain that the thrustplane had its greatest width, and consequent greatest movement, in about E. Long. 91° , or a little to the west, and it is impossible to realise the area below 1,000 square miles, while it may have been five times that. If we take the average depth at five miles, we find that the cause of the earthquake was the sudden and permanent displacement of not less than 5,000 cubic miles of the solid crust of the earth, and possibly of five times that volume."

CONCLUSION.

I have endeavoured to give you rather a glimpse of life in India—an account of an episode in an Indian official career—than a seismological discourse. Until observations have been tested by the Geological Department, it would be unsafe to draw conclusions from them. In calling this earthquake an

episode, I do not mean that earthquakes such as this are common in India. But where you have not earthquakes, you have other calamities. Twenty years ago, the coast of Bengal was devastated by a sea wave, which destroyed 100,000 people; ten years ago, a tornado gutted the most fashionable part of my own town of Dacca; and, three years ago, a similar tornado cut a line ten miles long, and a quarter of a mile broad, through villages a few miles from my house, producing a butcher's bill of 135 killed and wounded. The northern valley of Assam has its local plague, which has almost depopulated large areas. Where you have not battle, murder, and sudden death, you have plague, pestilence, and famine. I hope I have been able to show that as in the fighting on the north-west frontier, as in the famine in Upper India, as in the plague in the Bombay Presidency, so in the earthquake in Assam, we may be proud of the manner in which our fellow countrymen did their duty, and not only our fellow countrymen, but also our fellow subjects, natives of India in the service of the Government, on whom perhaps the burden and heat of the day, in times of stress and calamity, more directly falls. In his report to the Government of India the Chief Commissioner selects for special praise the native gentleman in charge of one of the sub-districts in the Assam Valley.

DISCUSSION.

The CHAIRMAN said he was confident that he expressed the feelings of all present in saying that they were much indebted to Mr. Luttman-Johnson for his paper. He ought not to detain the audience, as there were other speakers to follow, but there were just two points referred to in the paper on which he wished to say a word. The first was with regard to Mr. Robert McCabe. He was in his particular line perhaps the most remarkable man he ever knew in India, and had been his companion and guide on many a long day's march through the wildest parts of Assam. He (Sir Dennis Fitzpatrick) had had the good fortune to have working under him, both on the north-east and north-west frontier of India, some of the ablest frontier officers, and he must say that there was not one of them who, in the power of impressing these wild tribes with mixed feelings of awe and affection, the faculty of rapidly evolving law and order out of chaos, could be placed above Robert McCabe. The other point was with regard to the manner in which those who had to meet this terrible calamity faced the difficulties of the situation.

Mr. Luttman-Johnson had spoken of the conduct both of the Europeans and natives in this respect, and he must say that it was above all praise. This manner of facing trouble was of a piece with all that they had been hearing from India during the last eighteen months. The year in which this terrible earthquake occurred was in some sense an *annus mirabilis* for India. It was a terrible year, and he doubted whether such a congeries of calamities ever fell within so short a period upon any country or people. The way in which these calamities had been met by all, from Lord Elgin down to the very humblest person concerned, had won the admiration of all in England; and the patience and endurance exhibited by some, the courage and energy, the foresight and resource displayed by others, seemed to him to call for their warmest admiration, whilst at the same time it spoke well for humanity at large.

Sir STEUART COLVIN BAYLEY, K.C.S.I., C.I.E., said he had been asked as an old Assam official to say a few words on the subject of the paper, but practically most of what he had to say had already been said by the Chairman. He had wished to say a few words himself about Mr. McCabe, who was his friend also, and likewise something about the way the officials and non-officials, and especially the native servants, did their duty, but these points had already been touched upon. He congratulated Mr. Luttman-Johnson very much on the admirable way in which he had worked out this subject, and he took some credit to himself in the matter, as he first suggested that Mr. Luttman-Johnson should be asked to take this trouble on himself. He could assure them that since the year 1874, when Mr. Luttman-Johnson first went up to assist in the development of the new province of Assam—for Assam, as a separate province, was still under a quarter of a century old—there was no official who knew the whole of it so well, and he knew that they were securing in him one who would take all possible interest in the subject, and who could deal with it more graphically and ably than was given to most. He did not know whether Mr. Luttman-Johnson could claim to be an expert in seismology, but even if most of the audience were as ignorant as he himself was on the subject of earthquakes, he was sure that after hearing this paper they would have much clearer ideas on the subject than before. That was certainly his own experience. He wished time had allowed of the whole of the paper bearing on that topic being read, for there was a good deal which had been omitted, both on the subject of earthquakes and from the very human side of it as narrated by the officials at various places, which was both interesting and instructive. In the first part of the paper, the author had certainly made much clearer than he had before seen, the method by which the motion from what was called the central blow or explosion was communicated to the surface. He was, at first, a little inclined to criticise, and say—so far,

so good, but that does not help us to understand what the blow or explosion was, but for that they had to read the note of Mr. Oldham, which was referred to at the end, and those who did read it would, he thought, be appalled. He spoke in simple terms of the displacement of 5,000 cubic miles of the earth's surface. It had been very briefly explained how the force acted, but to have the subject worked out thoroughly was naturally a more intricate matter which could hardly be dealt with at the end of a lecture; but he should be glad if any one who had studied seismology would help to throw a little more light upon it. He could not but express his own deep regret at the pretty little hill-station of Shillong, with which he had so many pleasant associations, having been hopelessly wrecked. Any one present who knew it would, he was sure, share these regrets, and would sympathise with those who had lost their all; and some of the cases they had heard of had been very sad. He could only hope that the remarks offered on the subject of rebuilding the station in the future would be taken to heart. He hoped there would be no more large masonry secretariats or other buildings of two storeys. The terrors of former earthquakes, which were still lingering when he was there, were gradually dying out, and evidently buildings had been undertaken at Shillong, which the reputation of the old days might have made people hesitate about. The hints now given with regard to the buildings of the future were sound, and he hoped they would have their effect.

Col. Sir WILLIAM BISSET, R.E., K.C.I.E., said he had been asked to speak on some of the matters which came under his personal knowledge when in India. It would be interesting perhaps to know that living as he did on the summit of one of the small hills in Simla, he was disturbed from his seat on the afternoon of the 12th June by the disturbance which had been so graphically described. In Simla it was not alarming, not more so than those which on two or three previous occasions he had felt in previous years in the same house. But it was so marked, and the first shock was followed so rapidly by a second, that he at once sent to the telegraph office to ascertain where it had originated. But the telegraphic communication with the seat of this catastrophe shared in the general destruction, and the first information they had of the disaster was through a pencil message written by one of the officers who, hurrying back to Shillong on hearing of the calamity, sent back a policeman with a message down to the river, from which it reached the nearest telegraph office. It was days before those who were suffering in Shillong could communicate with the outer world at all. The destruction of telegraphs was not confined to the land lines, where the posts were both upheaved and sank into the ground and gave way in all imaginable ways, but the cables lying on the bed of the river Ganges were disturbed and torn, and also those in the Brahmaputra. That was

a remarkable evidence of the destructive power of this earthquake. With regard to the railways, the photographs had shown much better than any words could describe how they were damaged—in some cases the bridges subsided, the piers were twisted, sometimes leaning to one side, and sometimes the two sides of the river were compressed together and in other cases they opened out, so that in every conceivable way the railway structures were rendered useless. A large portion of the new railway which had just been opened, from the neighbourhood of Calcutta to Sylhet, was more or less damaged; in some parts the embankments settled down and spread out, while in other parts, for miles together, they disappeared. In other parts of Bengal the damage was less serious, but the picture of Nilfamari Station showed how in that part of the world the forces of nature were at work. Days elapsed before communication with Darjeeling could be established, and it was only by very great efforts that gradually, piece by piece, the line was restored. There was one very remarkable thing about this disturbance, and that was its influence, or rather absence of influence, on vegetation. To the best of his knowledge, and from inquiries he made, he learned that in all this large area of ground, beneath which this great convulsion had been going on, the growth of the trees, grass, and vegetation generally had not been disturbed. Attention had been called to the buildings in Shillong, and it had been very properly said that in the future buildings of the same class should not be constructed. He entirely agreed with that suggestion, and had already, before leaving India, put on record the desirability of avoiding solid structures in that neighbourhood. At the same time, he hoped that what Mr. Luttman-Johnson told them as to the non-recurrence of these violent disturbances, would prove correct, and that after visiting Shillong with this great calamity in 1897, the forces of nature would find some other place to vent their fury upon, and leave Shillong to grow up again to be the ornament of the rising province of Assam.

Correspondence.

STAINED GLASS AND MOSAIC WORK.

My learned friend Sir George Birdwood has not been concerned with the making of windows, or he would be aware that "mosaic" has long been an accepted technical term among glass-workers. I pushed it very little beyond its common use.

But, were it otherwise, I fail to see his contention, that mosaic should properly be opaque. It is not to the character of the material, but to the way it is used that the term applies. Sir George appears to think I called *pattern* glass mosaic, distinguishing it that way from *picture* glass. Perhaps I expressed

myself ill. What I meant to describe as mosaic was, a window made up of small pieces of self-coloured glass connected by lead or whatever it might be. It so happens that such windows naturally take the form of pattern work not of picture: but a picture so produced would be of course a mosaic.

I cannot profess the least penitence for my quite technical use of a technical term; nor even for any want of precision in my statement—seeing that we owe to it Sir George's very interesting letter.

In the matter of the diamond, I must profess myself of the 19th century. It seems to me, it would be absurd to go back to the "red hot pincers" and the grozing iron of the Middle Ages.

LEWIS F. DAY.

April 12th, 1898.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock:—

APRIL 20.—"Stage Mechanism." By EDWIN O. SACHS. SIR DOUGLAS STRAIGHT will preside.

APRIL 27.—"Photography and Colour Printing." By CAPT. W. DE W. ABNEY, C.B.

MAY 4.—"The Revival of Hand-loom Weaving." By MISS CLIVE-BAYLEY.

MAY 11.—"Water Gas and its Applications." By Professor VIVIAN B. LEWES.

MAY 18.—"The Evolution of the Cycle." By J. K. STARLEY. C. V. BOYS, F.R.S., will preside.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock:—

APRIL 21.—"Recent Railway Policy in India." By HORACE BELL, M.Inst.C.E. J. M. MACLEAN, M.P., will preside.

APRIL 28.—"India and Currency." By Sir EDWARD SASSOON, Bart. SIR DAVID M. BARBOUR, K.C.S.I. (late Financial Member of the Viceroy's Council).

MAY 19.—"Chartered Companies and Colonisation." By Sir ALFRED COMYNS LYALL, G.C.I.E., K.C.B., D.C.L. (Member of the Council of India). HENRY M. STANLEY, M.P., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday afternoon, at 4.30 o'clock:—

MAY 24.—"The Goldfields of British Columbia." By W. HAMILTON MERRITT. SIR CHARLES MALCOLM KENNEDY, K.C.M.G., C.B., will preside.

APPLIED ART SECTION.

Tuesdays:—

APRIL 26, AT 8 P.M.—"The Importance of Craftsmanship." By Sir WILLIAM BLAKE RICHMOND, R.A., K.C.B.

MAY 10, AT 4.30 P.M.—"The Art of William Morris." By F. S. ELLIS.

CANTOR LECTURES.

Monday Evenings, at Eight o'clock :—

DR. D. MORRIS, C.M.G., "Sources of Commercial India Rubber." Two Lectures.

LECTURE I.—APRIL 18.

Distinction between Caoutchouc and Gutta-percha—Occurrence of latex in plants—Constituents of latex—Natural orders yielding caoutchouc—Methods of extraction—Coagulation of latex—History of India-rubber—Progress of industry—Imports into United Kingdom—Relative production in foreign countries and British possessions—Uses—Value of total trade—Forms of commercial india-rubber—Present yield—Future supply—Para rubber-trees—Geographical distribution—Conditions of growth—Yield—Quality of rubber—Methods for collecting and preparing rubber—Commerce in Para rubber.

LECTURE II.—APRIL 25.

Peruvian and Bolivian rubbers—*Castilloa elastica*—Conditions of growth and exploitation in Mexico, British Honduras, Guatemala, Nicaragua and United States of Colombia—Venezuela and Guiana—Mangebeira—Maniçoba or Ceara—Matto-grosso—African rubber plants—Distribution of Landolphas—West African—East African—Mozambique—Madagascar rubbers—Lagos silk rubber (*Kickxia*)—Methods of preparation—Present condition of industry—Commerce—New sources of supply—Assam—Penang—Sumatra—Java—Borneo—New Guinea—Fiji—Cultivation of india-rubber plants—Prospects in Mexico, Brazil, West Africa, Ceylon, Malaya.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, APRIL 18... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. D. Morris, "Sources of Commercial India Rubber." (Lecture I.)

British Architects, 9, Conduit-street, W., 8 p.m. Mr. A. N. Paterson, "Domestic Architecture in the Eastern States of America in the Year 1896."

Victoria Institute, 8, Adelphi-terrace, W.C., 4½ p.m. Mr. Gerard Smith, "Design of the Human Foot."

North-East Coast Institute of Engineers and Ship-builders, Sunderland, 8 p.m.

TUESDAY, APRIL 19... Royal Institution, Albemarle-street, W., 3 p.m. Mr. T. C. Gotch, "Phases of Art: Past and Present." (Lecture I.)

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on paper by Mr. A. H. Preece, "The Electricity Supply of London."

Statistical, in the Theatre of the United Service Institution, Whitehall, S.W., 5 p.m. Mr. C. S. Loch, "Poor Relief in Scotland, 1791 to 1891."

Pathological, 20, Hanover-square, W., 8½ p.m.

Photographic, 12, Hanover-square, W., 8 p.m.

Zoological, 3, Hanover-square, W., 8½ p.m. 1. Mr. Ernest W. L. Holt, "The Breeding of the Dragonet" (*Callionymus lyra*). 2. Rev. H. S. Gorham, "The Serricorn Coleoptera of St. Vincent, Grenada, and the Grenadines." 3. Dr. Bashford Dean, "Note on the Affinities of *Palaeospondylus gunni*, Traq."

Colonial Inst., Whitehall-rooms, Whitehall-place, S.W., 8 p.m. Colonel E. T. H. Hutton, "A Co-operative System for the Defence of the Empire."

WEDNESDAY, APRIL 20... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. Edwin O. Sachs, "Stage Mechanism."

Meteorological, 25, Great George-street, S.W. 7½ p.m. 1. Major H. E. Rawson, "Anticyclonic Systems and their Movements." 2. Hon. F. A. Rollo Russell, "Results of Observations on Haze and Transparency in 1897."

Geological, Burlington-house, W., 8 p.m.

Surveyors, Town-hall, Manchester. 1. Mr. John Holden, "Manchester from 1847 to 1897." 2. Mr. T. Blashill, "Lessons from Fire and Panic." 3. Mr. C. P. Hall, "Present-day Difficulties met with in a Land Agent's Practice." 4. Mr. Howarth Chatefield Clarke, "Notes on the Construction of Town Buildings."

Microscopical, 20, Hanover-square, W., 8 p.m. Mr. H. D. Madan, "Some Organic Substances of High Refractivity available for Mounting Specimens." 2. Mr. E. B. Stringer, "Instantaneous Photomicrography." 3. Mr. H. Morlard, Exhibition of Diatoms."

Archæological Association, 32, Sackville-street, W. 8 p.m.

Mining and Metallurgy, Geological Museum, Jermyn-street, S.W., 8 p.m. 1. Mr. F. Hellmann, "The Determination of the Present Value of a Mine on the Rand." 2. Mr. S. Cowper-Coles, "Some Notes on the Recovery of Gold from Cyanide Solutions." 3. Mr. Wm. Terrill, "Notes on the Electrolysis of Argentiferous Copper." 4. Mr. Walter McDermott, "Notes on a Combination Mill in the United States."

THURSDAY, APRIL 21... SOCIETY OF ARTS, John-street, Adelphi, W.C., 4½ p.m. (Indian Section.) Mr. Horace Bell, "Recent Railway Policy in India."

Linnean, Burlington-house, W., 8 p.m. 1. Prof. Douglas Campbell, "The Structure of Dendrocercos." 2. Mr. W. P. Pycraft, "The Pterylosis of the Owls."

Chemical, Burlington-house, W., 8 p.m. 1. Messrs. C. F. Cross, E. J. Bevan, and Claude Smith, "The Carbohydrates of Barley Straw." 2. Dr. M. O. Forster, "Isomeric Borylaminates." 3. Dr. F. E. Matthews, "Some Derivatives of Benzophenone." 4. Dr. S. B. Schryver, "Researches on Camphoric Acid."

Society for the Encouragement of Fine Arts. Conversazione at the Royal Society of British Artists, Suffolk-street, Pall-mall, S.W., 8 p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Rev. Canon Ainger, "Some Leaders in the Poetic Revival of 1760-1820." (Lecture I.)

Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Discussion on Mr. R. Hamond's paper, "Cost of Generation and Distribution of Electrical Energy."

Historical, 28, Jermyn-street, S.W., 8½ p.m.

Numismatic, 22, Albemarle-street, W., 7 p.m.

FRIDAY, APRIL 22... Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. The Astronomer Royal, "The Recent Eclipse."

Civil Engineers, 25, Great George-street, S.W., 8 p.m. (Students' Meeting.) Mr. M. W. Henty, "New Cut Swing Bridge, Swansea."

Clinical, 20, Hanover-square, W., 8½ p.m.

Physical, Chemical Society's Rooms, Burlington-house, W., 5 p.m. Rev. T. Porter, "A Method of Viewing Newton's Rings."

SATURDAY, APRIL 23... Botanic, Inner Circle, Regent's-park, N.W., 3½ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Sir Walter Parratt, "Programme Music." (Lecture I.)

Journal of the Society of Arts.

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FRIDAY, APRIL 22, 1898.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****CANTOR LECTURES.**

Dr. D. MORRIS, C.M.G., delivered the first lecture of his course, on "The Sources of Commercial India-rubber," on Monday evening, 18th inst.

The lectures will be printed in the *Journal* during the summer recess.

INDIAN SECTION.

Tuesday, April 21; J. M. MACLEAN, M.P., in the chair. The paper read was "Recent Railway Policy in India," by HORACE BELL, M.Inst.C.E.

The paper, with a report of the discussion, will be published in the next number of the *Journal*.

Proceedings of the Society.**FOREIGN AND COLONIAL SECTION.**

Tuesday, April 5, 1898; The MARQUIS OF LORNE, K.T., G.C.M.G., in the chair.

The paper read was—

**THE BRITISH EMPIRE:
ITS RESOURCES AND ITS FUTURE.**

BY JOHN LOWLES, M.P.

My subject is a very vast one, and perhaps I ought almost to apologise for attempting to go over so large an area in the short time at my disposal; but I am thankful to say that in every department of life at home an increasing interest is being taken in the great subject on which I have the honour to address you to-night. If we look at our elementary schools, where the seeds of good

citizenship are being sown, the little action, which appears but a sentimental one, taken by Lord Meath and his colleagues, is an indication of the spirit of the times with regard to our great Imperial interests. In every Board school in my constituency, and, I think, throughout the whole of London, there has been placed within the last year or so a Union Jack in the principal room, a silent witness as it were to the imperial interests which, I am thankful to say, by means of brightly written text-books, are being studied more closely than ever before in our elementary schools. I have the honour to represent a large industrial constituency, and I have made it a practice whenever I have returned from a colonial journey to give illustrated lantern lectures. We happen to have a large town-hall, holding 3,000 people, and I have had as many as 10,000 people in three evenings of all classes and of all political parties—because we know no party where our empire is concerned—come to listen to what I have had to say about our great empire beyond the seas. In the House of Commons, as Lord Lorne will bear witness, an increasing interest is being paid to Indian and colonial questions. Whereas, in the old time it was the custom to bring on matters relating to the colonies and India at the end of the session, or the end of a sitting, we now find that, when matters appertaining to the East Indies or the colonies are discussed, a close, personal, and intimate knowledge is possessed by the members, which is evidenced by the interesting speeches they sometimes make on those occasions. Then, with regard to the utterances of our statesmen, it rarely happens, I think, that a week passes when speeches are being made by our leading statesmen on both sides of politics but we hear something of the great empire of which we are privileged to be citizens. Happily, the day has gone by when a man would stand and face a British audience, admitting that he was a Little Englander. They are getting fewer, I am happy to say, and in the House of Commons they are represented probably by only one individual who is not yet converted.

This intimate desire for a closer knowledge of, and acquaintance with, our Imperial concerns is not confined to this side of the empire. When I was in Australia a few months ago, almost the whole of the leading papers there were publishing a series of articles written by eminent men, entitled "Deeds that Won the Empire." So that on the other side of the

globe, in our great southern colony, the young and the old alike were being taught through the Press something of the greatness and the glory of their common ancestry, and of those deeds—as the title went—that won the empire. Then to come a little nearer home, I may refer, as an illustration, to my friend, Sir M. Bohnaggee. In him we have an object-lesson of the sentiment of a great industrial constituency in the heart of London. I know it was the personal charm of Sir M. Bohnaggee that attracted them in the first instance, but I am quite sure from my close knowledge of the constituency, because I am often in it, that they also had a feeling that they were not merely electing a representative who would look closely after their interests, but one who in a very special sense represented the great and important portion of the British empire, the great empire of India, from which Sir M. Bohnaggee comes.

It has been well said that our empire is one upon which the sun never sets, and Max O'Rell tells a story of a Frenchman who, on being told this, shrugged his shoulders and said the reason for it was that the English are such rascals that the sun is obliged to keep a sharp look-out upon them. However true the criticism may be the fact itself is true, for if we trace the times prevailing in the different portions of the British empire we shall find literally that while one portion of the good citizens of the empire are going to sleep some people in the other portions are just getting up and beginning their daily duties, so that it is perfectly true that the sun never sets upon the empire of the Queen.

We must not forget on what foundations this magnificent structure has been built up. We must go back to Elizabethan days, to those Western heroes of whom Kingsley was so fond of writing—Drake, Frobisher, Hawkins, Raleigh, and men of that stamp—and to that class of merchant adventurers who did so much to interest the British people in the empire beyond the seas. It was the men of that stamp who laid the foundations of that colonial empire which has been built up by stages ever since.

The earliest attempt at colonial settlement was made by Sir Humphrey Gilbert in Newfoundland in 1583. In 1600, the East India Company obtained its first Royal Charter. It is interesting, for the sake of comparison, to observe that the Company originally consisted of 125 shareholders, and for the great task that it undertook it had only a capital of £70,000.

Another interesting item, which perhaps some of us who do not look into history have not sought out, is that Charles II., who received as dowry with Katharine of Braganza the island of Bombay, leased it to the East India Company for the modest annuity of £10. The East India Company continued doing useful work under all sorts of adventurous circumstances until 1858, when their charter was extinguished.

By the end of the 17th century we had only added the New England States, St. Helena, two slave trading stations at the Gambia and the Gold Coast, the Bermudas, Jamaica, Barbadoes, and several of the minor West Indian Islands, New Brunswick, Nova Scotia, and Prince Edward Island, in the North Atlantic. At the latter end of the 18th and the beginning of the 19th century, we commenced an enormous expansion of our colonial empire in the West Indies, South Africa, India, Canada, and the Pacific; but it is in the reign of our gracious Queen Victoria that the greatest strides have been made, until to-day the British Empire is 53 times the size of France, 52 times the size of Germany, 3½ times the size of the United States of America, thrice the size of Europe, with treble the population of all the Russias. It extends over 11,000,000 square miles, that is 91 times the area of the United Kingdom; comprises a fifth of the human race, or 350,000,000 people. It embraces four continents, 10,000 islands, 500 promontories, and 2,000 rivers.

It is difficult, of course, sometimes to grasp the magnitude of these figures, but I think the best illustration I ever saw was in the British section at the World's Fair at Chicago in 1893. Nothing impressed me more than that corner of Jackson-park assigned to Great Britain and her colonies and dependencies, because there one saw in miniature, as it were, the whole British Empire gathered together in one spot. There were the houses and buildings in the style peculiar to the various lands and colonies they represented; there were natives from all parts of the globe; and there was the British flag flying over each of these houses—each of these nationalities—and men were found of every colour and every creed bound together by the one common sentiment of loyalty to her Majesty, and by the common pride of being citizens in the same great empire.

Before proceeding to glance rapidly over some of the resources of our empire, let me say at once that wherever we go over that vast

area, we find ample evidence of the old British characteristics of self-dependence and independence, and that we, whose proud heritage it is to be free men, and to thoroughly enjoy the blessings of civil and religious liberty, readily extend those privileges to those over whom we rule. Those who have had opportunities of travel like myself, and of observing and tracing the difference between British and foreign rule, cannot help feeling that there is something about British rule which seems to suit almost every nationality. We do not, on the whole, have the difficulty with native races that foreign nations do. Take, as an illustration, the North American Indians. In Canada one meets them, as I met them six weeks ago, walking about the cities free men and free women with their heads erect, and evidently feeling the blessings of liberty. You go into the States and you see very few Indians, except in the reservations to which they have been driven, and in which they are kept. The treatment is so different, that in the one case you see something like free men and free women, proud of their citizenship, and conscious of equal justice at the hands of their rulers, and in the other they seem to be a frightened crowd, always more or less at issue with the powers over them, and living a very different life from those who live under our flag. The same thing is seen in other portions of the empire. It was my privilege when in Queensland to meet the Governor of New Guinea, Sir William Macgregor, who, during the ten years that he has administered the British section of that island has done magnificent work. He told me that it was as safe for a white man—who, by the way, is strangely called by the natives *Jesu Christo*—to go about New Guinea to-day as it was for him to walk about on the mainland of Queensland. But only two months before I was there, just across the border, on the German side of the island, the natives, apparently still untamed and fierce, had killed the Governor. I asked Sir William Macgregor how it was, and he said his effort had been, during the whole ten years of his administration, to pacify the natives, who were always more or less at war with each other; but he had invented the idea of enrolling his police from the different tribes, taking them to Port Moresby, keeping them for a couple of years under discipline, teaching them to maintain themselves, and sow their own mealies, and grow their own food. At the end of that period, when they were thoroughly disciplined—when they had learnt

self-respect, and something of the blessings of civilisation—he would send them back to their villages to act as representatives of order, with the effect that the whole country became more or less pacified.

The same thing might be said of the native races at the Cape, in Australia, in New Zealand. In New Zealand, for instance, what a magnificent illustration there is of the capacity for government of the British people. Of course New Zealand was acquired by the goodwill of the Maories. There I saw, in the New Zealand Parliament, huge dusky Maories, magnificent fighters, and enemies worthy of our steel, when unfortunately at war with us, sitting side by side with Englishmen administering the laws of the colony in which they lived. This is a splendid tribute, I think, to the capacity of the British people, not only for self-government, but also for inculcating the principles of self-government in the races over which they rule.

If I speak somewhat boastfully, it is because, whenever I return from a long colonial trip I always come back prouder than ever of being a Britisher, and prouder than ever of being a citizen of this great city of London. There is no place in the world where liberty is enjoyed as it is in Great Britain, and under the British flag. I was coming the other day up the Irish Channel on one of the Cunard boats, and there was a party of Americans who had never been to England before; they were talking about their own great country, about liberty and so on, and asked me if I had seen the statue of Liberty in New York Harbour, and the bell at Philadelphia. I had to confess that I had found the statue very hollow and shaky, and I had seen the Liberty Bell at Philadelphia with its magnificent inscription, but unfortunately the first thing I noticed was a great crack from the top to the bottom. I am afraid that hollow statue and that cracked bell are almost synonymous of what American liberty is. It was a beautiful March day with the sun shining, as it has been shining to-day, and the white cliffs of Anglesey were reflecting the sun, and I said to these ladies and gentlemen: "If you want to know what liberty is, just take the deepest breath you can, and you will taste it."

I think Lord Lorne was present when that magnificent specimen of a loyal French Canadian, Sir Wilfred Laurier, the present Premier of Canada, was speaking in London during his Jubilee visit. What did he say? He said that while he was proud of his French

ancestry, and that he was a Frenchman by descent, he recognised that he would never have enjoyed the same liberty under the flag of France as he and his compatriots enjoyed under the flag of Great Britain.

We see also the capacity for self-government in the municipal life in the colonies, not only in the large cities. I had occasion when I was in West Australia to take a long journey. It was very hot, and I remember the first well I came to; it was about one-third water to two-thirds grasshoppers; every time you opened your mouth, like "poor Mrs. Somebody," you swallowed a fly. I remember coming to an out-of-the-way place about 100 miles from anywhere, consisting of about 100 inhabitants, but even here I was met by a Progress Committee, who in emulation of the City of London, presented a beautiful address to a representative in Parliament from the old country, not indeed emblazoned on vellum, nor enshrined in a gold casket, but written on a half sheet of foolscap with a torn edge. This Progress Committee represented an embryo municipality.

I recently crossed the Atlantic with Mr. Ogilvie, that intrepid explorer who has just come from Klondyke, and he told me that even in Klondyke, amongst the British section of the miners at any rate, the principle of municipal life existed. Whenever they had to decide anything they met in council, and they abided by the decision of the majority, and as a rule that decision was pretty well right, so that I am not merely using a sentimental phrase when I talk about these characteristics of self-dependence and independence, which are peculiarly British, and stand us in such good stead in every part of the world.

Then I think people are beginning to recognise, at all events those who have money to invest, that there is something stable about the British law, that the security of the British flag and the British law count for something, and that as far as law can give security, they will be secured wherever the British law extends.

Wherever we go in the colonies we find great progress in education, both elementary and advanced. Great sacrifices have been made by some of the colonies in order that their young people may grow up with a capacity to fit themselves as good and worthy citizens of the country to which they belong. Further evidence of the progress of civilisation in the colonies is found in the following figures.

In 1875 only 7,121 miles of railway were open and 22,116 miles of telegraph; in 1895 (20 years later) 33,716 miles of railway were open and 119,228 miles of telegraph. The total sum spent on construction of railways to end of 1895 was £348,000,000. As most of the railways are owned by the State you will see what a source of profit they have been, and what a good security they form for the loans of the colonies where they have been constructed. It is satisfactory to note that the receipts were £23,000,000 against £14,000,000 expenditure, a profit in working of £9,000,000.

The Premier of the Cape told me when I was there in August last, that but for the railways her revenue would cut a very sorry figure. They were extending them in all directions, and they were a source of very great profit to the Government.

It is interesting to note that whereas the total trade of the colonies in 1875 was under £215,000,000 sterling, it had risen in 1895 to £300,000,000, and this in spite of the enormous fall in values. If the latter factor is taken into consideration it would probably be shown that the trade has doubled itself in the course of two decades.

It may be interesting to glance for a moment at some of the items which go to make up the total of £150,000,000 of exports from the colonies:—

Wool	..	..	..	..	£30,000,000
Sugar	..	..	..	..	7,000,000
Hides, skins, leather, and furs	..	..	..	..	6,000,000
Gold	..	..	..	..	10,000,000
Silver	..	..	..	..	3,500,000
Copper	..	..	..	..	1,250,000
Tin	..	..	..	..	1,500,000
Iron	..	..	..	..	1,000,000
Coals	..	..	..	..	4,500,000
Corn and flour	..	..	..	..	5,000,000
Live and dead meat	..	..	..	..	4,000,000
Timber	..	..	..	..	3,000,000
Diamonds	..	..	..	..	4,000,000
Other precious stones	..	..	..	..	5,000,000

The total mineral production of the empire, including United Kingdom, is valued at £100,000,000 per annum.

Dairy produce also figures largely and promises to increase rapidly, as also do fish, fish products, tea, coffee, fruit, &c. It is estimated that the empire possesses one-third of the sheep of the whole world; one-fourth of the cattle; one-twelfth of the horses; one-fourteenth of the pigs.

In shipping the colonies stand exceedingly well, owning 1,411,707 tons (Canada largest), which added to 8,988,450 tons registered in the

United Kingdom, and 52,325 tons in India, gives the enormous total of 10,452,482 for the British Empire.

Another satisfactory sign of material progress in the colonies is seen by the amount of deposits in the savings banks, which stood at the end of 1895 at the respectable total of £41,500,000.

I have ventured to present these figures in the gross, as giving us a collective picture of some of the resources of Greater Britain.

I will now rapidly survey the principal portions of the Empire.

United Kingdom.—Area, 121,000 square miles; population, 40,000,000.

I remember striking terror into the heart of a member of Parliament in Western Australia, when I told him that I sat for a constituency covering one square mile in the heart of London, containing 60,000 people. He raised up his hands in pious horror, and said he sat for a constituency of 500 square miles in extent containing just 37 souls. The map here, which is not a very large one, will give you an idea by those areas coloured red of the extent of the British Empire. If we go westward of the British Islands, we come first to Newfoundland, which was acquired by settlement. I am just going to show how we acquired these colonies; it was not all by conquest. I myself feel a very keen sympathy with those brave pioneers, men who have gone out with their pick and their shovel, and who in a quiet way have helped to build up the British Empire. They do not get the same recognition as the soldiers who fought so gallantly for us; they do not figure so largely in history, but to my mind they deserve, from an Imperial point of view, just as much credit as those who helped to build up the Empire with the sword. Now, Newfoundland is a very fishy place. It is the greatest fish emporium in the world, and a very loyal and progressive colony. It has had its set-backs like other parts of the empire, but Newfoundland is a country of vast resources, and I think is on a fair way to renewed prosperity.

Then we have that great *Dominion of Canada*, where the memory of your rule, my lord, and that of your gracious consort is treasured to this day. I had the privilege of meeting one whom you know very well in Ottawa, Sir James Grant, and he told me more than one pleasant story illustrating the kindness and goodness of your Lordship and the Princess during your rule in Ottawa. Canada was acquired partly by conquest and partly by settlement. When we think of

Canada and its history, we cannot help, in passing, giving some evidence of our satisfaction, when we think of the memory of Wolfe. You land at Quebec, and go to the heights of Abraham, and there you see a plain monument with this inscription—"Here died Wolfe, victorious." This magnificent Dominion of Canada has an area of 3,500,000 square miles; a population of 5,000,000 with room for 70,000,000. I have often wondered why the United States—which is really only 200,000 miles more in area, and rather less if we count in the whole of Canada, but taking the portion that might be settled—should have a population of 70,000,000, while Canada has only 5,000,000. Canada has enormous resources, and I am very thankful that a recent great find has happened just within the Canadian border. I do not know how it is but I think it is a very happy circumstance that this great new goldfield, this new Eldorado, happens to be just within the British border. The Canadians mean to make the most of it; they mean that the British people shall have the first chance in acquiring some of this new found wealth within their northern borders. I always look upon Canada as the great wheat-producing country. Quite recently at an exhibition in London Manitoba hard wheat secured the first prize against all comers. I remember at the World's Fair at Chicago being astonished at the wonderful show which Canada made on that occasion. In every department of dairy produce and in agricultural machinery, in which the United States was supposed to excel, Canada more than held her own, and as a rule it was Canada that took the first prize and the United States the second. The timber resources are marvellous. I remember being taken to Stanley-park at Vancouver, and standing beneath trees of huge girth which seemed to me to be very like the monument at London-bridge, rearing up their heads 100 to 150 feet—giants of the forest—which made one feel very small indeed when standing beneath them. With regard to minerals, from Nova Scotia in the east to British Columbia in the west, and from Rossland in the south to Klondyke in the north, the whole land is simply permeated with minerals of one kind or another. I think the most sober judgment might well be staggered when it attempts to calculate the mineral wealth of the Dominion of Canada. Mr. Ogilvie, whom you all know is a very sober conservative man, told me less than a month ago that he estimated that £20,000,000 worth of gold would come out of the Klondyke region

alone this year. If that is the case it will be twice the normal yearly out-put of the gold within the whole of the British Empire. We have a magnificent illustration of the enterprise of the citizens of Canada in that Great Pacific Railway which stretches for 3,000 miles from Montreal to the coast. It is a remarkable illustration of what can be done by enterprise to remember that every day from the eastern end a train starts and from the western end a train starts, and goes right across that mighty continent. Then we have the waterways of Canada, they are magnificent waterways. I wish that Canada could spare to Australia some of her water. I think Australia would be the most perfect country in the world if it could get a little Canadian water to help it along the dry seasons. Canada has been fortunate in her statesmen, and I need only cite the names of Sir John Macdonald, Sir Charles Tupper, and Sir Wilfred Laurier, as men who have looked into the future. My idea of a statesman in contrast to a politician, being that a statesman, to be worthy of the name, must have the gift of foresight. These men have been worthy of the best traditions of British statesmanship, because they have looked ahead, and they have seen how much depended on cheap transport. When I was last in Montreal, a little time ago, a steamer came down from Port Arthur, laden with grain, and was able to go right through the St. Lawrence on her way to Liverpool. That is a magnificent testimony to British enterprise, and I am quite sure the money sunk is well invested, because when, as I hope, we put Canadian wheat in front of the United States and Russian wheat, about which I shall say something later on, Canada will then reap the fruit of her foresight in these magnificent means of cheap transport by her waterways, which extend 2,400 miles from Lake Superior to the sea. Canada has not been unmindful of her obligations in the matter of defence. She has a permanent militia of 36,000 and reserves of over 1,000,000 men. I crossed from Australia with a most enterprising colonel of one of those regiments, who is also a member of the Dominion Parliament. He had been to Australia with the patriotic idea in his mind of getting the Australian colonies to combine with Canada in order to form an Imperial brigade ready to be sent anywhere, and to do anything, either in the service of the mother country, or in the service of any of the sister colonies.

Then we have *Australasia*, that magnificent

heritage of the southern hemisphere. It was acquired by discovery and settlement, and not by conquest. It has an area of 3,175,000 square miles; a population of about 5,000,000, with room, I might say, for 100,000,000 more. We know its products are various, and of enormous extent; wool, meat, wine, minerals, timber, and sugar. I happen to have gone right through Australia recently, and, therefore, I am rather full of Australasian matters.

First, we will take *Queenland*, the north-eastern section of Australia; its gold production to the end of 1896 was over £40,000,000; tin, £4,000,000; coal, £2,000,000. In 1896, Queensland produced wool to the value of £3,000,000. Queensland to-day, in spite of her dry seasons, supports over 7,000,000 horned cattle, 19,000,000 sheep, 500,000 horses; and I could have bought a very good "nag," if I had had an opportunity of using it, for 15s. when I was there. She has a permanent defence force of 3,000. I had the privilege when I was there of seeing the greatest gold mine in the world, Mount Morgan, 26 miles from Rockhampton. Originally, it was a dairy pasturage, belonging to two brothers named Morgan—all Morgans are milkmen, I believe. They sold this pasturage for £16, and three brothers put in £500 each by way of investment. Those gentlemen are living to-day in the metropolis, drawing, as a result of their investing £500 each, over £35,000 a year in dividends. It produces very nearly £750,000 of gold each year; and Mr. Jack, the government geologist of Queensland, one of the most able men in the profession, told me there was ample evidence to his professional eye that this great mountain of quartz extends 160 yards across, and that there was enough in sight to produce that result for 500 years to come—a very good look-out for those who have invested in Mount Morgan shares.

Then we come to *New South Wales*, the mother colony down in the south-east; her gold production to the end of 1896 was over £43,000,000, her silver, £24,000,000, chiefly from the Great Broken Hill mine; and her coal, £31,000,000. She has a Newcastle, well-named after our great northern coal port, with magnificent coal resources of good quality. Her tin production was £10,500,000. New South Wales possesses over 2,000,000 horned cattle, 57,000,000 sheep, and 500,000 horses. In 1896, she produced 303,000,000 lbs. of wool, valued at £9,000,000. She has a permanent force of over 8,000 men.

Victoria comes next, the smallest but perhaps the wealthiest and most populous of

the Australasian colonies. And there we have this striking fact that the gold production of Victoria to the end of 1896 (and, remember, Victoria is hardly fifty years old) was £247,000,000 sterling of the precious metal. Many of her mines which were closed down 10, 20, or 30 years ago, are now being reopened, and I myself went down a mine there, 1,400 feet deep. There is one 3,000 feet deep, and they say it is getting so hot there that they doubt being able to go much further. Victoria possesses over 13,000,000 sheep, and her dairy industries attain very large proportions. Enterprise is extending in the direction of what until lately was regarded as vermin, namely, the rabbits. I saw myself one shipment. I was taken to see the cold storage set up by the Government in Melbourne, and I saw 48,000 rabbits being sent over to England in one shipment. I think they fetch 9d. each in the metropolis, which leaves a very handsome profit after the shipping charges are paid. If one travels about, one sees how potential the resources are. I was taken into the storage of one vineyard where 600,000 gallons of wine were stored, and the lady who owned the adjoining vineyard, while growing grapes on the magnificent surface soil, was receiving a royalty of £50 a week from miners who burrowed under her land in order to get at some alluvial deposits which ran like a river through the whole course of her property.

The gold production of *South Australia* is much smaller, but her copper production up to 1896 was £21,000,000 sterling. The gold was £1,815,000. In 1896, *South Australia* produced wool valued at £1,288,000. They have a smaller number both of sheep and cattle—337,000 cattle and 6,323,000 sheep. The wine of *South Australia* ought to be really more appreciated in the English markets than it is. It is of very high strength, and pays a much greater proportion in duty in consequence, than the cheap wines of the Continent. I tasted some there which really compared with anything I ever tasted on the Continent or at home. I think they have a just cause of complaint against the mother country in letting their wines come into hotch-potch, as it were, paying for its virgin strength, which they cannot help, without reducing it by water or some other form of adulteration. They think, at least, the duty ought to be calculated in an *ad valorem* way, so that the people here might have the benefit of the cheap wine that they produce—not cheap and nasty, but cheap

and good compared with the wines of the Continent.

Now we come to the vast colony of *West Australia*. It spreads over nearly one-third of the Australian continent. It is 975,000 square miles in extent, and until lately was regarded as the Cinderella of the colonies—it was the dumping ground for convicts for a considerable time. I remember travelling on that journey I was speaking of just now, and having to spend a night at a sheep station—not a crack sheep station, such as I visited in New South Wales, but just a branch sheep station, where I had to sleep on a mattress of a very doubtful colour, and with a mud floor. I saw a remarkable combination there. There was an old man with one arm, one with one eye, and one with one leg. They all seemed about the same age. I got into conversation with the cook, the man with one eye, and a very good cook he was, in spite of having only one eye. Our food was very crude; our only illuminant was a wick stuck in a pickle bottle. There were no knives and forks, we had to take the mutton chops in our fingers, and eat them in that way, but of course we had to adapt ourselves to our environment. There was no butter on our bread, no milk in our tea, but the old man did bring me a piece of soap and a candle, and they were regarded as such luxuries, that I think they had been treasured up for a year or two. I wondered how it was that these three old curiosities were there. The man who was driving me told me they were “lags,” that is to say, convicts; they came out as convicts in the old times, they were farmed out, and were just using their lives up on the sheep station in the way I have described.

I found some very remarkable people in Western Australia. I met a John Bull there, and I met a W. E. Gladstone. John Bull had gone out 35 years ago, an assisted emigrant from Bristol; by his own energies, and by his own strong arm he had secured somehow 400 acres of land, and he told me he had raised amidst many difficulties, in what appeared barren soil, magnificent fruit trees, and he derived an income the year before I was there of £2,000 out of those 400 acres of fruit farming. W. E. Gladstone keeps a baker's shop, and they call it the premier bakery. *West Australia* has been regarded as being a perfectly barren place, but within the last three years it has produced £6,000,000 worth of gold; but in addition to this it has large pastoral resources, and it has also belts of very fine agricultural land. I myself took

up a little land when I went out there in 1896, and I went to see it for the first time last year. To my great surprise land which was a virgin forest, although possession had only been held for nine months, had 300 acres under crop, flourishing splendidly, although it had no outside assistance beyond the ash of the trees in order to fertilise it. The effect of the gold rush in West Australia has been (and the effect of the gold rush in Canada will be the same), to develop all the other resources, because the gold area cannot grow what it wants for its requirements, and there is an enormous demand. West Australia last year had to import £800,000 worth of produce for consumption; so that there is a very fine field for people who are not disposed to go and search for gold—they can find gold in developing the other resources of the country.

Tasmania is a beautiful place with a beautiful climate, and it is also a most flourishing colony.

New Zealand, the Britain of the South, has great natural beauties which well repay the journey to see them, and has besides enormous natural resources, which will, I believe, continue, and flourish for a long time to come. New Zealand has produced gold to the value of £52,000,000, and she exported wool last year to the value of £4,391,000. She possesses 1,138,000 cattle, 19,000,000 sheep, and 250,000 horses.

The total gold production of the Australasian colonies is valued at £344,000,000 up to the end of 1896, while other metals bring the total up to the enormous figure of £460,000,000 sterling. One ought to reflect that this industry gives employment to other industries—it creates a demand for machinery from Great Britain. It is estimated that in connection with mineral workings something like £6,000,000 worth of machinery is used, and the last return gave the number of men employed at the various mines at 102,000.

I pass rapidly on to the *West Indies*, with *British Honduras* and *British Guiana* on the South American mainland. The total area is 120,000 square miles, with a population of 1,800,000. The principal industry—sugar—is very depressed; but I hope the time is not far distant when, by some methods which at present are perhaps in the minds of our statesmen, and have not yet been disclosed, we may counteract the pernicious effect of those foreign bounties, and give our sugar-producing colonies a chance. I wish doctors would recommend raw sugar as they recommend whisky. I think

if people had any regard for their stomachs, they would not eat and drink as they do in solution the beet-sugar, which is produced on the Continent, but the magnificent raw sugar which comes from the West Indies or Queensland. Most of the sugar produced in the colonies is very much better for the health, and would be very much better for the pocket, to both the producer and the consumer, than that horrible production which is made from beet on the Continent.

Then we come to *Africa—South, West and East*, acquired partly by conquest and partly by settlement or annexation. It has 2,500,000 square miles, and a population of 5,000,000. There we have wool, wine, gold, diamonds, and ivory, produced in apparently illimitable quantities. The evidences of the richness of that great continent, which was rightly called till a few years ago the Dark Continent, are becoming manifested every day.

Then we have *Ceylon*, 25,000 square miles only, in extent, but an island which is a beautiful place to visit, and most productive.

The *Straits Settlements*, which with the Protectorate cover 26,000 square miles, are an exceedingly busy and useful item in connection with British trade.

Then there is the island of *Hong Kong*, the importance of which, I think, is becoming more manifest every day. Hong Kong is about the third shipping port in the world, and is a magnificent tribute, I think, to the expansion which follows the British flag. I was privileged to be in the House of Commons to-day, and I am quite sure, without any distinction of party, we welcomed the straightforward statement made by the First Lord of the Treasury. There is no doubt the nation was in a state of uneasiness for a time, but the policy of the Government has been justified. Mr. Balfour explained, in the most lucid way, that they had succeeded in getting three new ports open to trade in China, one quite in the interior, and they had also succeeded in absolutely neutralising, as far as possession by foreign Powers is concerned, the river Yangtse. They also were driven by force of circumstances, much against their will (because their policy was to keep China open for commercial purposes without adding anything to their responsibility by acquiring territory) to get that position at the entrance to the Gulf of Pechili at Wei-Hai-Wei, through the action of Russia at Port Arthur. Mr. Balfour

explained, and it was a most delicate thing to do, something of the negotiations with the great Eastern Power, which showed that the British Government, had been driven to this position. I am quite sure that we shall all rejoice that what threatened to be a loss of prestige in the East has been converted into a triumph, and that Great Britain stands where she did before, the predominant nation in that part of the world.

Last, but not least, that magnificent *Empire of India*, with an area of 1,700,000 square miles, with a population of 288,000,000, speaking 778 languages, excluding European, claims our attention. The importance of India to British commerce is manifest when I tell you that five-sixths of the trade is British; the total import trade in 1895 was over £59,000,000 sterling, £43,000,000 of which were from Great Britain and £7,000,000 from British possessions, making £50,000,000 in all from British sources, leaving £9,000,000 only for all the other nations of the world. India furnishes native forces amounting to 220,000 men, and I am quite sure that those who know India will agree that although there may have been blots on our administration—and it is almost impossible in a great country like that with so many varied interests for the most able rulers to sometimes avoid making mistakes—on the whole the administration has been carried out with benefit to the native races, always with equal justice, and the weak had been protected in every part of that great empire.

There remain to be mentioned the naval and military posts at *Gibraltar*, *Malta*, *Cyprus*, and *Perim*. There is a curious story about *Perim* told me by an old P. and O. captain, and it is this, that a certain French commander put in with his vessel at *Aden*, and was invited courteously to the house of the Governor, was entertained, and there he let out after dinner—some people talk freely after dinner—that he was bound for a little place higher up the Red Sea—namely, the Island of *Perim*, and he was going to plant the French flag there. His host was more hospitable than ever, and he found another bottle of that good old wine which the French officer liked so well; but in the meantime he sent a message to the captain of an English ship in the port, and by-and-bye when Monsieur finished his visit and proceeded to fulfil his mission he found the British blue-jackets posted and the British flag flying on the Island of *Perim*.

To conclude this survey we have *Aden*, *St. Helena* and *Ascension*, and coaling stations and naval stations in every ocean, and we have recently had an illustration of the advantage of having coaling stations and good coal there too, in the case of our eastern fleet. But for our coal stores at *Hong Kong* we might have been reduced, like the Germans, to having to beg from our neighbours. When I was in *Vancouver*, I had an illustration of the foresight of the Admiralty. I went to see the magnificent naval station at *Esquimaux*. There I found that they used nothing but Welsh coal, so as to make sure of having the most reliable combustible when quick and difficult work has to be accomplished.

I do not think I could have dwelt for a much shorter time on the resources of the empire: they are so vast, but I very much hope that in the figures I have tried to give you I have not wearied you. After all, it is a matter of figures when you are talking of the resources of the empire.

Now, if I may, I will just for one moment talk about the future of the empire. The importance of this question has been recognised by men who, as I say, are deserving the name of statesmen. The great Professor Sir John Seeley, who did so much to impress the importance of the study of English history on English people, did a great and quiet work. I remember, in the East-end of London, hearing of men who were sent out by Professor Seeley to go into the school-rooms connected with the various churches and chapels, and talk to the people about the importance of the British Empire. Professor Seeley said this:—

“I tell you that when you study English history, you study not the past of England only, but her future. It is the welfare of your country, it is your whole interest as citizens that is in question while you study history. How it is so, I illustrate by putting before you this subject of the expansion of England. I show you that there is a vast subject ripening for decision, upon which almost the whole future of our country depends. In magnitude, this question far surpasses all other questions which you can ever have to discuss in political life.”

That was the opinion of a great student on a great subject. Now I venture to say the most important question with regard to the future of the empire is the trade question. We have in our colonies, as I have shown you, great producers of raw materials. We have here a huge consuming population who live, the bulk of them, by their work as artisans, and by manu-

factures. What is more natural, what is more logical than that there should be a basis of exchange between the manufactured articles of the old country and the raw materials of the new countries. I venture to say that as these great natural and inexhaustible resources of the colonies are developed, we shall find, not merely increased profitable employment for our artisans at home, but we shall find, also, increased opportunities for men with large families who have not elbow-room enough at home. That is a part of the question I mean to dwell upon by-and-bye. My impression is that the State ought to give opportunities, not by pauperising her people, but by offering facilities to those who desire it to settle in other parts of the empire in order that they may make new homes for themselves where they may have plenty of room to get profitable employment. In support of this opinion of mine, that the trade question looms the largest, and is the most important in connection with the future of the British Empire, I want to quote, if I may, just briefly Lord Salisbury, and Mr. Chamberlain, than whom no one has given closer study, or is more able or more qualified to speak upon it. Lord Salisbury in referring to the question of closer commercial union said:—"It is an organic question which concerns, and will control, the very existence of our empire, and the very foundation of our trade."

Mr. Chamberlain has spoken thus on the subject:—

"We may, however, approach this desirable consummation by a process of gradual development. We may endeavour to establish common interests and common obligations. When we have done that it will be natural that some sort of representative authority should grow up to deal with the interests and the obligations we have created. What is the greatest of our common obligations? It is Imperial defence. What is the greatest of our common interests? It is Imperial trade. And those two are very closely connected. It is very difficult to see how you can pretend to deal with the great question of Imperial defence without having first dealt with the question of Imperial trade. Imperial defence is largely a matter of ways and means, the ways and means are dependent upon the fiscal and other commercial arrangements you may make, and, therefore, the conclusion to which I arrive is this—that if the people of this country and the people of the colonies mean what they have been saying, and if they intend to approach this question of Imperial unity in a practical spirit they must approach it on its commercial side."

Mr. Chamberlain on the same occasion further said:—

"To organise an empire—one may almost say to create an empire—greater and more potent for peace and the civilisation of the world than any that history has ever known—that is a dream if you like, but a dream of which no man need be ashamed. We appreciate and we cordially respond to the notes, the stirring notes of loyalty and affection that have been evoked from our colonies when the great mother country has appeared to be in danger. We look forward with hope and with confidence to the development of those countries which are populated by our children and by our kinsmen, but those sentiments alone will never make an empire unless they are confirmed by bonds of material interest, and we can only found unity upon a common weal."

Happily, these opinions are shared by leading men of all shades of politics. Lord Rosebery, not in precisely the same words, but with precisely the same meaning, has expressed his views on this subject. Happily, the feeling is spreading throughout the whole of the colonies. Canada long ago declared, and actually put on record in the statute-books of her Parliament that she was ready when the mother country was prepared to discuss the question, to give British manufactures a substantial preference in her markets. Of course there have been standing in the way as you know, those two unfortunate treaties with Belgium and with the German Zollverein, which prevented our Colonies giving any preference to goods of the mother country, but happily, the courage of our statesmen rose to the occasion. I thought that the whole country would be about their ears, at least, some of the misguided people who cling so closely to some of the old traditions that have guided them too long, when it was announced those treaties would terminate. It had been announced that the Governments of Germany and Belgium would not expunge the particular clauses to which I refer, so our Government did a bold and statesmanlike stroke when last year they gave notice that those treaties must terminate, and by the end of June, this year, those clauses will be expunged, and new treaties will be in force, and we shall be free for the first time to set up reciprocal relations with our colonies.

Canada has done more than this. It was my privilege a few weeks ago to sit on the floor of the Parliament-house at Ottawa when both sides—and both sides in Canada vie with each other in the desire to draw closer together the bonds between the mother country and themselves—agreed to re-shape their fiscal arrangements, and they have definitely offered to give to the mother country a preference of

10, 15, and, in some cases, 20 per cent. in her tariffs over the produce of other countries. I had the privilege in 1896 of going to Australia as honorary Commissioner of the United Empire Trade League. In Canada of course, being a federated dominion, they speak with one voice, but in Australasia there are seven voices, there are seven colonies, and the difficulty was to get them at all into line on this great question. They had an idea that their fiscal liberty was going to be interfered with. It was my privilege to interview those Governments, and at the suggestion of one of the Premiers—who depend a great deal more for guidance upon the people perhaps than do our statesmen at home, I mean that they do not lead, they rather follow—I addressed a meeting in Melbourne Town Hall, when perhaps 3,000 persons were present. A favourable resolution was moved and enthusiastically carried, so that the Victorian Government at least were set free to act on the affirmative side of this great question. The Premier of New Zealand—and those of you who saw him last year know what a bold and vigorous man he is—was going to the country the following year, and he actually put this as the first plank in his platform: “I am for Imperial unity upon the lines of Imperial trade,” and he cut out the suggestions which I submitted to him, put them into his election address, and elected to stand or fall by them. The result was that he was returned by a large majority in order to carry out that policy which he had so boldly set forth, which is a tribute again, I think, to the common-sense of British people wherever they may be. You can understand personally how pleased I feel to hear by telegram that at Melbourne at a conference of the Australasian Premiers, on the 11th of March, this resolution was passed:—

“That the federal tariff should give preference to the produce and manufactures of the United Kingdom, and in default of an early federal tariff the colonies should be recommended individually to give a substantial preference.”

That, I think, is a magnificent testimony to the good sense of the Australasian Premiers. Now we have Canada and South Africa and Australia, all in line on this great question. I know there are differences of opinion as to what the next move should be. My own opinion is that the mother country should frame a policy and submit it to her daughter countries in various parts of the world. Anyhow, we have the testimony in

black and white that each of our great self-governing colonies is prepared to meet us by giving our products substantial advantages in her markets, and I think it is only natural that they should look and hope for some advantage for their own products in return.

I have already dwelt upon the resources of the various colonies. Let me bring the matter to a practical issue. A resolution was brought forward in the House of Commons, last Session, that the Government should buy a six months’ supply of wheat, and store it here in case of emergency. It is a very striking fact that we get our bread every day brought to our doors, but we do not stop to think what is our reserve of wheat. The fact is, that on the average there is less than a month’s supply of grain in the country. Seeing that out of 30,000,000 of quarters of wheat consumed each year, we have to import about 25,000,000, it is a very serious question as to what would happen if the grain supply were stopped. My belief is that the best way in which we can store grain, is to make Canada the granary of the empire. Canada is within a week’s steaming of the mother country, with magnificent natural resources; she has actually a larger grain producing area than the United States has, and its quality has been shown, as I have testified by the premier position occupied in every exhibition at which her products are displayed. My own feeling is that there is a grave national danger in depending on foreign countries for our food supply, apart from their not taking any notice of the questions of give and take. On the average we pay the United States of America £90,000,000 a year chiefly for goods that we could get in our own colonies just as well, and, I think, a good deal better. Whereas the United States only spends with us £30,000,000 a year, thus obtaining an advantage of £60,000,000 on a trade of £90,000,000. Our colonial customers are of very much better value to us than that. They say to us in effect for every pound you spend with us we will spend a pound with you. I think we can so arrange matters as to prevent our colonies becoming great manufacturers. Some, indeed, have set up industries which are flourishing, but their natural bent should be to develop their raw produce, their natural resources, and if we can establish relations by which their produce is given a preference in our markets, and our manufactures a preference in theirs, there is no limit I think to the expansion of trade which would take place between us. If one studies, as I do,

the figures which come out each year in the Statistical abstract, it is a very striking and alarming fact that the whole of our increased import trade this last year or two with foreign countries has been in manufactured goods. It is a very serious question for our artisan population. I think last year the increase was about £7,000,000 all in manufactured goods. Where are we to look for outlets for our manufactures but to those great new countries which are capable of such infinite expansion beyond the seas, and which actually offer to treat us preferentially in exchange for some sort of consideration on our part for their produce? I remember in Queensland, just before I was there, there had been a deputation from France. In France you know they have a minimum and a maximum tariff, and they can impose which they please. Some French people had been to Queensland offering them the advantage of the minimum in return for some concessions. What did the Premier say to me? Sir Hugh Nelson, a thorough Britisher and a thorough statesman, said, "How is it that you do not do something to ensure a preference for our meat?" As I tell you they support 7,000,000 horned cattle, and beef is a great staple article in Queensland. They say if they can get 1d. a lb. net for their beef, the producers in Queensland are quite content. You add to that of course charges for chilling and for freight, making it about 1½d.; so that they want to get about 2½d. in the London market. They say they cannot get it. I do not know where the profits go to, but I would be very glad to buy Queensland meat for 2½d. a lb. if I could get it. But they say the competition from the United States and Argentina drives the market down to below a payable rate, sometimes to 2½d. or 2d., and the Queensland producer cannot get a living price, although the paying price is only 1d. per lb. for the meat he produces. In South Africa we have evidence of patriotic feeling. It was during the existence of the present Government that that great statesman, Mr. Rhodes (who, with all his faults, has done magnificent service to the empire) made a definite offer when that great country which bears his name was being opened up, that he would give British products a distinct preference in the markets of that great country on a definite reciprocal basis. His offer was not entertained, and for some reason or other no notice seems to have been taken of it, but I think it was evidence of his desire—and I heard Mr. Rhodes himself say that such was his de-

sire and ambition — to find employment, not merely for willing hands in South Africa itself, but for our struggling artisans at home. There is this to be said to his credit, that the great railway for which he was largely responsible has been built with material bought in Great Britain, and the produce of the labour of British artisans.

I have, perhaps, dwelt too long upon this all-important subject, but there is just one other point I should like to touch upon. I mentioned it in passing just now, and that is, that apart from the trade question, there is the question of State-aided emigration. Of course we do not want to deport the flower of our labour — either agricultural, or from the manufacturing centres — but those who, like myself, have an intimate acquaintance with the lives lived by some of our people, know how many men with large families find it difficult to make both ends meet, and to find profitable employment for the growing boys and girls of their families. In West Australia lately they told me they were giving £3 a week with a cottage to married men for their labour, and 30s. to single men in the house with their food. Surely it is time to put aside the old prejudice about being exiled from home. One feels just as much at home in these distant parts of the empire as if one were living within the sounds of Bow Bells. Everything is British, although it was certainly curious when I was in Brisbane on Christmas-day, with the glass standing at about 110°, to hear the carol, "See amid the winter's snow." But anywhere, if you adapt yourself to your surroundings, as you very soon would, you would feel that the same elements really—British flag, British law, British feeling—exist in any part of the empire where you may settle.

I hope I have not exhausted all the time that is open for discussion, and that some other views besides my own will be expressed. I have ventured just to say that in my idea the future of the empire and the maintenance of its greatness and prosperity depend very largely on the promotion of these two questions, the trade question, and State-aided emigration. At all events I venture to hope that we shall have at all times at our disposal large-hearted and large-minded statesmen. The day of the Little Englander, as I have already said, has departed, and I am sure of this, that a bold policy, one which looks at the matter from a high standpoint, and from the standpoint of material interests, will meet with approval on

the part of the people of this country. I very much hope that we shall always find the British spirit displayed, as Tennyson so well expressed it when he said—

"We sailed wherever ship could sail,
We founded many a mighty state;
God grant our greatness may not fail,
Through craven fears of being great."

DISCUSSION.

Sir M. M. BROWNAGGREE, K.C.I.E., M.P., said he could not let the opportunity pass without expressing his appreciation of the admirable manner in which Mr. Lowles had treated his subject. He had on previous occasions read articles on his colonial experiences contributed to some of the metropolitan papers by that gentleman, and had been led by their perusal to come and hear this paper read, and must gratefully acknowledge that he had not been disappointed. Mr. Lowles had dwelt with just pride on the great work done by past generations of Englishmen in founding the glorious Empire known as Greater Britain, and he believed that all who had heard him were convinced that but for the spread of that Empire, millions of human beings would never have enjoyed the privileges and means of enlightenment which had been theirs for many years. The keynote of England's greatness as a colonising power was struck when Mr. Lowles said that wherever the British flag floated, and the British soldier planted his foot, there, hand-in-hand, went freedom and justice, the two great guarantees of the permanence of British rule abroad. Other nations, jealous of Britain's greatness, had tried, especially in recent years, to rival her in establishing colonies, but he felt sure that they would strive in vain to compete with her. In England freedom had gone on broadening from principle to principle, and so long as there were Britons of the type of Mr. Lowles, who, amid the pressing duties of a busy life, found time to visit the most distant parts of the empire, and see for themselves in what the greatness of that empire consisted, and how it could be maintained and developed; and so long as Britain did not forget that the strength of her empire lay in the maintenance of freedom and justice among whatever people owned her sway, so long neither the competing trade nor the narrowminded jealousy of other nations would be successful in rivalling her power and influence in different parts of the globe.

Mr. W. R. ANTHONY said he had listened with great interest to this paper. He knew Mr. Lowles's work amongst the masses in the East-end, and how thoroughly he had devoted himself to the study of the great and important questions with which he had dealt, and which not only all statesmen, but all thoughtful men should keep in view, especially bearing

in mind our rapidly increasing population and the vast responsibility of our extended empire. The question of reciprocity between the mother country and the colonies was one of great importance, seeing that we had in London alone from 80,000 to 100,000 persons constantly unemployed. Why should this be so when Providence had opened a natural door for our surplus population, not as had been pointed out by going into exile in a strange land, but under the British flag where they might help to build up a great empire? There was the island continent of Australia; there could not be a nobler destiny for a young Englishman than to go forth and take his part in building up an empire there or in South Africa. He agreed cordially with Mr. Lowles on the question of reciprocity with the colonies. Some years ago a great financial authority, so-called, though he never regarded him as such, thought it just and fair to the colonies to cheapen the duty on French wines and abolish the differential duty in favour of Cape wines, which were just beginning to command a sale, and were soon squeezed out of the market. He thought there should be a distinction made in favour of our own flesh and blood as against the foreigner. England had gained the position she held by virtue of free trade, and he was a freetrader, but that did not prevent reciprocity between different sections of the Empire as against hostile interests. We had had to fight with one hand tied behind us, because, as Lord Salisbury said, we had nothing to give, but that need not prevent our trying to draw nearer together the ties of blood and fellow-citizenship, which should bind the Australian, the South African, and the Canadian, all in one hand with the English, Irish, and Scotchman, and the Indian in Hindustan. We were all one great country, and anything done in the way of reciprocity should be looked at in that light. No one outside could complain because they did not belong to the British Empire. It was quite legitimate, in his opinion, for a freetrader to advocate reciprocity between the mother country and the colonies. Another point of great importance was the question of national defence. We had not a sufficient food supply in the country, but lived in a fool's paradise, thinking we could never be blockaded or have to submit to a naval defeat. If such a thing were to happen, were they to be starved into surrender as the Parisians were in the Franco-German war? It was a question which statesmen really ought to take into serious consideration. Lastly, with regard to State-aided emigration, though it was perfectly true that prosperity had been increasing by leaps and bounds, and we had 50 per cent. fewer paupers now than 40 years ago, in spite of the increase of population, nevertheless we had a great many paupers, who might be very well provided for by State-aided emigration. He was very glad to see the Marquis of Lorne, who also represented an industrial constituency, in the chair, when questions of such vast importance to the working-classes were brought forward.

Mr. JAMES McKILLOP, M.P., said the country, and even the Government, were under a great debt of obligation to gentlemen of patriotic spirit like Mr. Lowles, who went all over the world, and brought back such valuable information. The colonies presented themselves as the future field of State-aided emigration if necessary, as it might be, with the increased pressure of population. We could not always be the manufacturers of the world, and population would no doubt continue to increase. In the near future the colonies would start manufactories of their own, thus to some extent closing the market to British goods, but there were large areas of unlimited resources available for emigration.

Prof. WILTSHIRE said they had received a good deal of information on many important subjects. Clearly, our increasing population required some means of exit in greater degree than had been afforded hitherto, and the colonies were the countries to which we should look. The food question again was very important. There were rumours of war in every direction, and if England were not to be starved out, as she might easily be, some provision ought to be made against such a contingency.

Captain YATES said, when he came home after a residence of 17 years in the East, he found the people of England knew very little about the British Empire, and he, therefore, hoped this paper would be very widely distributed. The great secret of John Bull's success was that, first of all, take him all round, he was honest; secondly, he respected everybody's religion; and, thirdly, he respected their women. That had been his experience in Gibraltar, Italy, Aden, Egypt, and India, and so long as those qualities were conspicuous, there was no likelihood of the Englishman's rule proving a failure.

The CHAIRMAN, in proposing a vote of thanks to Mr. Lowles, said they were much indebted to him for the charming panorama he had painted, and also for the thoughts he had expressed—arising from his survey of almost the whole of the English-speaking world, indeed, more than that, for he had included India. It was a good thing for public men to adopt the habit of what had been called "globe trotting," and seeing for themselves what Englishmen over seas were doing. Formerly it was not the fashion, and he could not recall the visits of more than half-a-dozen M.P.'s during the whole time he was in office in Canada; or indeed of even so many rejected candidates. He used to be rather indignant sometimes, when he heard of distinguished Englishmen making a tour through the United States, and being interviewed, but not coming nearer Canada than the suspension bridge and the Falls of Niagara. But that was all altered now. As time went on, it became more pleasant to travel; hotels were more numerous, and were now excellent both in Canada and in Australia, and no doubt men would travel far more than

they had been accustomed to. A friend of his, describing a journey in Australia, said they had to subsist for a day or two in the interior on rattlesnakes, and in some parts of Canada they would not be able to get even that. But as a rule, so long as they kept to the beaten track, travelling had become very easy, and accommodation was excellent; in fact, in many cases better than was generally found in Great Britain. In India, people were willing to take passages along the coast in steamers by no means so well fitted up as they had to be on the Australian coast if the vessels' owners wanted to get any custom at all. What a difference there was, too, between the present days and the old in many other respects. Speaking of unity, for instance, in the days before the Union, Mr. McKillop's forefathers and his own were all intensely interested in what was called the Darien Scheme, which was a great Scottish scheme of colonisation; but English merchants were so jealous of the plan that almost everybody connected with it was ruined. Now everybody, English, Irish, Scotch, and Welsh, pursued their projects for increasing their business, and were encouraged by the whole force of the empire. That was why we had expanded so much; forces, instead of being turned against each other, and thus wasted, had been utilised in the expansion of the empire at large. Reference had been made to the success which Great Britain had attained in making subject races contented. He believed that was because we proceeded in a liberal spirit, and allowed much more individual liberty than other nations, which were more tied up with bureaucratic red tape. Take the German, for instance: he did not go abroad to carry with him the institutions of the German Reich; he went to get away from them, and to escape the conscription. The Englishman went with the express intention of planting his own institutions and the mode of government under which he had lived, wherever he went. That, amongst other things, had made us a great colonising power, and what an enormous interest we got on the capital so laid out. They had all listened to the voice of a Canadian in the person of Albani, and to an Australian in the person of Melba, so that the race, whether in Canada or Australia, did not deteriorate but was capable of as fine development and beauty of vocal utterance, as in the old country. With regard to Klondike, he believed there would be found there, as in the rivers of California and British Columbia, an enormous amount of gold in the gravel. Whether they would come to the bedrock gold was another question, but if they did, the climate, which was so terrible, need not frighten anybody, as they could go to a considerable depth, where the cold would not penetrate. One of the great benefits of the rush would be that those who went there, even if they failed in finding gold, would have, at all events, the opportunity of seeing what life in Canada was like, and in all probability a fair sprinkling of them would settle down on the fertile prairies of Manitoba or Assinboia. He was not anxious for a

rapid filling up of the country, thinking it much better that colonies should grow slowly, and consist mainly of those who went to settle, not of those who made a rush to get rich, who would settle anywhere for a time, and as quickly depart if they thought there were greater chances elsewhere. Colonisation in Canada was slow but sure, and by that means they had a population more homogeneous, who settled there because they liked the institutions of the country and desired to live under the British flag. He should have been glad to hear more about Australia. He believed the great project of confederation was now nearing its conclusion, and he should not wonder if the great events now taking place in China—the augmentation of the power of Japan in those seas, and the presence of Russia and Germany—made the Australians think it wise to sink any personal differences and present an unbroken front to the rest of the world. Then came the very difficult question of what was called reciprocity. Mr. Lowles thought the best plan was for the colonies to produce the raw materials and for England to work them up; but he would venture to say that in every large colony, rising into manhood, you would always find a strong desire to become self-contained. They would not be satisfied to be called, rightly or wrongly, mere hewers of wood and drawers of water; they would insist to some extent on having their own manufactures and their own workmen. That being so, and it being impossible to impose direct taxation on a young nation, and indirect taxation being inevitable, it became a question how much preference you would give them if they gave a preference to you? It could not be all “give” on one side; it must be “take” also. They would have to cast round ultimately, and see what preference they could give them in return for what they offered. That seemed to him was the problem of the future, which must be solved, not by one side being mere producers of raw material and the other mere manufactures, but by both partaking to a certain extent of that character. He entirely agreed with what had been said on the subject of emigration; he did not know of any country which had expended much money in what might be called exporting its own adult population. Government might work for the interchange of population in other ways, by cheapening communication for instance, which was a most important point. He thought it would be wise for England to meet any offer from the colonies for cheapening communication by a like offer. Quite lately the Canadian Government were anxious for a fast steamer service, and offered £104,000 a year towards the expense. England replied that she would find £52,000, just half, which he thought was not enough. It was by giving cheap passages to emigrants more than anything else that you induced people to change their domicile. Until the price of a passage across the Atlantic is reduced below £3 he did not think there would be that movement which they would like to see of adult

people. But he did not think State-aided emigration should begin with adults, but with children. There was a great objection on the part of the colonies to receive much adult labour, trades unions would be up in arms at once, but there was not the same objection to healthy children being sent, if proper homes were provided for them. He should like to see in every union, or in every county, some place where children could be trained, much as Dr. Barnardo trained them, to take part in colonial life, both boys and girls. That was proceeding along the line of least resistance, and much might be done in that way. He concluded by again expressing his appreciation of the manner in which Mr. Lowles had made his statistics interesting.

The vote of thanks having been carried unanimously,

Mr. LOWLES briefly acknowledged the same, and desired to express his thanks to the Marquis of Lorne for his kindness in presiding.

SEVENTEENTH ORDINARY MEETING.

Wednesday, April 20, 1898; Sir DOUGLAS STRAIGHT, Member of the Council, in the chair.

The following candidates were proposed for election as members of the Society:—

- Callan, William, 2, Coleman-street, E.C.
- Cory, John, J.P., D.L., 4, Park-crescent, Regent's-park, W., and Duffryn, Cardiff.
- Gray, Matthew Hamilton, Lessness-park, Abbey-wood, Kent.
- Luttman-Johnson, H., Alenho, Ridgway, Wimbledon, S.W.
- Kingdon, G. H. K., 47, Lovely-lane, Warrington.
- McKeone, Henry, 18, Addison-gardens, W.
- Madho, P. Beni, Jodhpur. Rujputana, India.
- Mathers, Edward Peter, Glenalmond, Beckenham, Kent.
- Riley, Lionel Vincent, 10, Throgmorton-avenue, E.C.
- Walker, James Lewis, 178, Queen's-gate, S.W.
- Watts, Philip, Elswick Shipyard, Newcastle-on-Tyne.
- White, James Martin, Balruddery, near Dundee.
- Wood, John Alfred, Kenmore, near Eltham, Kent, and 2 Coleman-street, E.C.

The following candidate was balloted for and duly elected a member of the Society:—

Starley, John Kemp, Barr's-hill-house, Coventry.

The paper read was—

STAGE MECHANISM.

BY EDWIN O. SACHS.

INTRODUCTION.

A movement, known by the name of "Stage reform," has of late years received some attention in this country. It originated some twenty years back in Austria, with the primary object of encouraging the greatest possible imitation of nature in the *mise-en-scène* of opera and drama. The rudiments of art, as understood by painters, sculptors, architects, and the cultured public of the day, were to be applied to the stage, and a true scenic art was to take the place of the nondescript, irrational and frequently coarse mounting previously given to plays. To facilitate the efforts of the scenic artist, the fullest application of our modern sciences (notably of mechanics and hydraulics) in the interest of "Stage reform" was considered essential, and the introduction of recent methods of lighting was also deemed necessary. The numerous fatal conflagrations, which had originated on the stage, caused the question of protection from fire to be closely associated with the movement, while the frequency of dangerous diseases among the members of the dramatic profession preserved the claims of hygiene from neglect.

The movement, as I have said, originated in Austria, soon after the terrible "Ring" Theatre fire at Vienna; and, on account of the prominence accorded to protective measures against fire, much headway was at that time made in German-speaking countries. Able exponents were found among leading artists; and stage-managers, architects, engineers, firemen, and last, though not least, the Government and municipal authorities interested themselves in the matter. Since then the movement has not only surely and gradually developed throughout Austria and Germany, but also spread beyond the frontiers of those countries. Concurrently, some quite independent movements also originated amongst several other nations, and though the purposes of these were not identical, they were very similar. Throughout Europe a transitional period may be said to have begun for the stage. Up to the present time, however, this period has nowhere attained its desired termination in any generally recognised reform. No definite new era has yet been opened, even in the countries where the movement first obtained a footing. Experiments have been numerous and various, and the failures have

almost outnumbered the acknowledged successes. The boldest experiments, with their valuable achievements and costly failures have, however, now been made, so that little remains to be done, except the practical and systematic application of the experience gained. I may here at once say that I see no reason why the experimental or transitional period of the movement should not now be superseded by a new and definite epoch, more especially if the matter is taken up by men who are free from fads of their own.

The primary object of the originators of the movement, *i.e.*, the closest possible imitation of nature, has in several instances already been attained, but the art world, and the cultured also, have found that this generally means crude realism. The mystery of the *mise-en-scène*, so necessary to a good scenic picture, is lost, and much also of the so-called "feeling" of the spectacle is lacking. Modern science and the most recent methods have already been employed to some purpose in the interests of the mounting, but stage managers and experts have found that an extreme modernisation of the scenic artist's auxiliaries often means more complication and uncertainty than was formerly the case. The expenditure incurred by *extreme* reform on the stage has often been found to be disproportionate to the advantages to be gained therefrom.

Both in the effects to be obtained, and in the methods to be adopted, *practical* reform is now gradually taking the place of *radical* reform. There can be no doubt that the exponents of the extremist movement have given the necessary impetus towards the improvement of the scenery, and future generations will be greatly indebted to them. As is usually the case, however, with any radical reform, the originators of the movement are scarcely likely to see their proposals adopted in their entirety. Nevertheless, they may be well satisfied that a moderate and practical outcome of their efforts is assured. And this is a great deal when we consider to what an extent the stage clings to tradition and convention, and repudiates any interference from outsiders, and how sweeping the proposed reforms appeared twenty years back.

In England the primary object of "Stage reform," the imitation of nature in the *mise-en-scène* of both opera and drama, has certainly found a fair amount of favour. This, however, is virtually due to the manner in which the public have associated the movement with that crude realism which has of late

met with so widespread an appreciation in all branches of art and letters. There has been no outcry against the indifferent mounting of a play, and the realism of a spectacle has generally been more appreciated by an audience than its merits as a work of art. "Stage reform" in this country is still associated with the sensational shipwreck, the race, or some other exciting item of the programme, and any popularity of the movement is practically due to the rendering of such realistic scenes. There have not yet been many instances where art alone has helped the movement, but for that matter, perhaps, we have not seen many examples of a *mise-en-scène* on truly art lines.

With very few exceptions, on a small scale, no extreme reform has been attempted in this country as it has in Austria and Germany. This is largely due to the fact that our actor-managers have to rely on their own purses or on those of some speculative financier, instead of having a certain proportion of public funds placed at their disposal. Our managers cannot afford expensive experiments. Too much risk is involved in the sudden departure from traditions and conventional usages, and the most that can be undertaken is a gradual improvement of the scenery on the old lines. Such improvements, as distinct from extreme reforms, there certainly have been. Sir Henry Irving, of the Lyceum Theatre, is a notable exponent of moderate reform. The late Sir Augustus Harris, our leading *impresario*, has also done much in the gradual beautifying of his scenes on recognised lines, though he was frequently hampered by the fact that his productions required a too realistic mounting of the ultra-sensational kind.

If we wish to see a *mise-en-scène* on art lines, the outcome of extremist experiments, we have only the private stage at Bushey, where Hubert Herkomer, who at one time took a leading part in the movement in England, has, at his own expense, achieved numerous successes as a stage-manager and scene-painter. His miniature stage has been a working model from which our actor-managers have learnt much. Those who have had the good fortune to see one of the Bushey performances will have realised the difference between nondescript mounting and really artistic scenery. The general public little knows to what extent the efforts of Hubert Herkomer have affected stage management. Without his private experiments, it is hardly probable that even Sir Henry Irving's stage

would have shown such improvements as are now accepted as a matter of course.

The curious feature, however, of the movement in England, is not so much the absence of extreme changes in the scenery of our stage, as the almost entire absence of the application of modern science and modern methods in the interests of the stage management. Even the few exceptions which do exist generally concern only the substitution of electricity for gas in stage lighting, or some minor or mechanical appliances to facilitate what is termed a "quick change." We are for once untrue to our national reputation for practical adaptations; and this, moreover, in a case where there is unlimited scope for energetic young engineers. In this country, again, the question of fire protection has not been associated with the movement, and the advancement of stage hygiene seems scarcely to have been considered by our exponents of "stage reform." The former omission is, of course, quite in keeping with our traditions. We insure our property and never consider the tremendous national loss by fire, nor do we take measures for the protection of life from fire until some great catastrophe has fallen upon us. But in the matter of hygiene, such neglect is unusual in a country which prides itself on its leadership in matters connected with sanitation.

I now propose to show how far modern sciences and methods have already been brought into the service of stage management, and how the protection of audiences and of *employés* has been attended to, as far as the arrangement of stage is concerned. I do not intend to formulate any model code of requirements, or to describe any model stage of my own. This paper will solely indicate examples of stages erected during the last twenty-five years in which attempts have been made to fulfil modern requirements with the means at our disposal at the end of this great century of technical progress. Earlier examples of stage machinery are not dealt with, as these can easily be explained from what I shall term a typical example of the English stage of to-day. There is little difference between the ordinary London stage of 1897 and the stage of 1700. The electric light may have incidentally taken the place of the limelight and gas of recent years, or the candles and lamps of an earlier period, and, as I have observed, there may be some "tricky" mechanical detail or slight improvement in the minor gear; but such unimportant contrivances, I am afraid, com-

plete the list of changes made. Even where the *mise-en-scène* is improved so much as at the Lyceum Theatre, the antediluvian wood stage still remains. London, however, is not the only city, nor England the only country, where such lack of progress is observable. Modern stages are as yet rare abroad, except in the countries where stage reform originated. The only difference is that, while some of the oldest and worst stages in London have been known to show excellent mounting, good scenery abroad will, as a rule, only be found on a modern stage; and I will here take the opportunity to express my admiration at the perfect scenic arrangement of some of our plays, for the production of which our managers are so greatly hampered by their pitiable stage equipment, which compels them to have recourse to innumerable makeshifts. It would, however, be impossible for the London manager to do such excellent work if he had to change his play-bill daily, as is frequently the case on the continent. The so-called "set-pieces," for instance, could not then be so extensively used as they are now. It is probable that plays with long runs in which the stage carpenter's work becomes mere routine have partly been the cause of our tardy progress in stage reform, while the more complicated requirements of a continually changing play-bill, must have assisted the movement abroad.

Before going further, I may mention that, with a view of studying modern stage mechanism, I have personally visited most of the theatres on the Continent possessing modern stages. Every facility was granted me by the authorities in every case, so that it is not without a full knowledge of the most recent developments that I have ventured to address you to-night. I must, however, as an architect, claim your indulgence for any errors of expression in dealing with a subject which rightly belongs to the allied profession of the engineer. But, curiously to say, no English engineer seems to have as yet given the stage and its possibilities any special thought. And what is more, no English stage mechanist nor carpenter has ever given us any publication dealing with the wood stage of old that might serve as a basis for my remarks. I am, therefore, practically broaching an entirely new subject or section in that vast world commonly known as "Technical Science."

It would certainly be premature to attempt any rigid form of classification in so new a subject. The exact definition of the headings

seems to me practically impossible. It would, however, be well to note that stages may readily be grouped according to the materials of which they are constructed. I will, therefore, use the main divisions:—Wood Stages, Wood-and-Iron Stages, and Iron Stages; and I will also make further subdivisions according to the power chiefly employed in working the appliances. These subsections are:—Manual Labour, Hydraulics, Electricity. Owing to the almost entire absence of steam for motive power in connection with stage machinery, a separate division for appliances where steam is employed is not required. I first take the Wood Stage, then the Wood-and-Iron Stage, and, lastly, the Iron Stage. Manual labour is employed in all three, but electricity and hydraulics are only to be found in connection with the latter. Hence the division of the subject is practically as follows:—

Wood Stage.—Manual labour.

Wood-and-Iron Stage.—Manual labour.

Iron Stage.—Manual labour, hydraulic power, electric power.

Before, however, speaking of the Stage, I must particularly call attention to the purposes of the various classes of playhouses for which scenic paraphernalia have to be provided. This may at first sight appear out of place, but I hold that if the purposes of the different institutions are borne in mind, it will greatly facilitate the appreciation of the circumstances which govern the construction and working of stages, and the structural as well as the economic difficulties which have to be overcome. I must also remind you of the necessity for studying the planning of a modern playhouse, more especially in regard to the stage and auditorium, for it should be clearly remembered that stage mechanism is not everything, but that the sighting and acoustic properties have to be considered. The outlines and dimensions naturally depend in the first place on the respective requirements of the stage-management or owner; but in the same way as the lines of the auditorium are essentially governed by the proscenium opening, the setting-out of the stage is regulated by the height and width of this all important feature. Many stages have so-called rear or back stages, the dimensions of which are, however, dictated mainly by the facilities to be afforded for obtaining certain effects. Altogether I would emphasise the fact that the engineer who wishes to give attention to the subject of stage construction must fully comprehend the requirements and possibilities, and it is absolutely essential that he should not

only know the wishes of an individual client, but also the varied policies or makeshifts necessary under different circumstances, and above all in different countries. In my work, "Modern Opera Houses and Theatres," and in various papers read before the Royal Institute of British Architects, the Architectural Association, and elsewhere, I have already spoken of the very different manner in which theatre construction is treated by the architects of the Continent, as compared with the way in which it is dealt with in this country. I have laid some stress on what I might almost term the difference of "feeling" which pervaded theatre architecture, and it would not be out of place to repeat that there exists a considerable distinction between the artist and leader of his profession, who is responsible for the Continental building, and his more practical *confrère* of our own metropolis.

In the same way as there is a decided contrast in the character of those responsible for the erection of theatres in this country as compared with those on the Continent, so there is a wonderful difference in the *personnel* responsible for the construction and working of the stage. With few exceptions, the construction of our stages is in the hands of a stage carpenter, who has had no exceptional advantages in the way of technical training, and whose position in the theatre is hardly better than that of any foreman of artisans. Abroad, even for the construction of wood stages, the commissions are given to fully qualified engineers who hold influential positions in their profession. More particularly, in German-speaking countries, there is a distinct calling of stage engineering, and though some few of the present leaders may have risen from the ordinary stage carpenter this profession is practically now only composed of men whose preliminary training alone often approaches that of our Royal Engineers. The body of stage engineers includes men with exceptional powers of initiative, as may be judged from the examples of hydraulic and electric stages which I propose to show, and the way in which the work is usually executed, also displays, I am glad to say, such full consideration for the requirements of the scenic artist, as is but seldom found where the interests of art and science clash. In several instances even, the stage engineer takes also the position of "director of scenery" (*Artistischer Leiter*), and is held responsible for all stage effects, including the design of the scenery, which is prepared under his

supervision. This last-named combination of offices in one man, I certainly do not hold with, and I would add that the arrangement is but rarely successful. I prefer to see the mounting of a play in the hands of a scenic artist of recognised standing, to whom the engineer and the principal of the painting room should be able lieutenants, and not collaborators on an equal footing. One mind alone should govern the mounting of a play. All the larger theatres of the Continent, it is noticeable, employ permanent engineers whose appointment is mostly in the gift of the owner, and is held continuously irrespective of any change in management, lesseeship, or varying appointment of scenic artist.

It is not my intention to indicate how much the scope of the engineer depends on the individual in charge of the stage—in other words, the stage manager, lessee, or actor-manager, as the case may be—nor do I wish to speak of the various circumstances on which depends the amount of attention the mounting of a play receives, what effects are attempted, and what methods are employed. All this would lead too far, though, to repeat, it is essential for the theatre-engineer to be versed in the varied requirements that he may be called upon to consider. I cannot, however, when speaking of the modern stage, omit some mention of expert opinion on scenic art and its auxiliaries, for nothing has so materially influenced the recent development of stage mechanism as the candid criticism of recognised authorities.

In the first place, let us look at the question purely from the artist's point of view. The distinguished artist, Hubert Herkomer, holds "that the real secret of perfect scenic art lies in illusion," *i.e.*, in visual deception, or in not allowing the eye of the spectator to discern the means whereby the semblance of reality is obtained. Mere actuality will not accomplish this any more than good painting *per se*. It is in the attempt to get absolutely every requisite effect by painting that so much mystery is lost on the stage, for the scenic artist's art should be as much concealed as that of the actor. It should not be too manifest whether a background is painted or modelled any more than that an actor is "made up" or appears in his natural form. Let us remember that an actor whose wig, for instance, is so badly fitted that his own hair was visible, would not be tolerated for a moment, and yet the public will accept a street-scene painted on a canvas that is moved by every draught, a rose bush cut out of thin boards, or a moon rising very quickly

straight up the sky and then remaining stationary. Do not forget that it is quite safe to let down a wobbly sheet of canvas close to the footlights, with a scene painted thereon representing breakers dashing over the rocks, and perhaps a sinking ship in the distance, to which the actor may have to refer in his speech. It is safe to have layers of canvas hanging from the "sky" like so much washing hung on a line; and certainly but few have ever questioned the prerogative of the "firmament" to come together at right angles in the corner. Why, it would take almost a volume to describe the many anomalies of scenery constantly observed on the London stage.

Again, from the stage engineer's point of view, authorities abroad have published opinions which are not so very unlike Herkomer's. They assume that the desire for realism which pervades the 19th century has completely changed the ends and aims of modern scenic art. The decorative artist, like the actor, must know how to be in earnest. Actor and scene painter alike must above all so labour that the audience shall forget that they are within the four walls of a theatre. But our old stage methods prevent the realising of such an aim, and the impression of an audience that they are only witnessing a play is often far too palpable. Why have the horizon cut horizontally by a crease, showing where the cloth has to be canked? Why let our beautifully-painted panoramic scenes jerk along according to the jerky manner in which the scene-shifter handles his drums? The panoramic scenes may cost £1,000, and yet the simplest mechanical contrivance to ensure their smooth working is grudged and the effect entirely spoilt.

Surely this is not as it should be. Does it not seem curious that in these enlightened times the theatre should still have to develop behind the back of society, and that the memory of the former condition of things still clings to matters theatrical? Truly the actor of to-day is treated well enough by society; he is no longer a vagabond and a stroller. Nevertheless, the stage still occupies an exceptional position; it is still to a large extent ignored by the State and by Science. Let us look at the matter even from the most prosaic point of view—its commercial aspect. Science has turned industrial; she tins meat and condenses milk, but she has not troubled herself about the stage. We employ the same wasteful methods as if modern science were

non-existent. Surely it is time to wake up to the necessities of modern entertainment!

Now this paper is obviously intended to deal with modern stage mechanism, and it is hence necessary that I should allude to the wooden stages which are being built every day in the metropolis and in the provinces, and which, by some curious anomaly, embody, as far as we are concerned in this country, our modern forms of equipment, though this equipment, with but trifling exceptions, is identical with what we have been used to for the last 200 years.

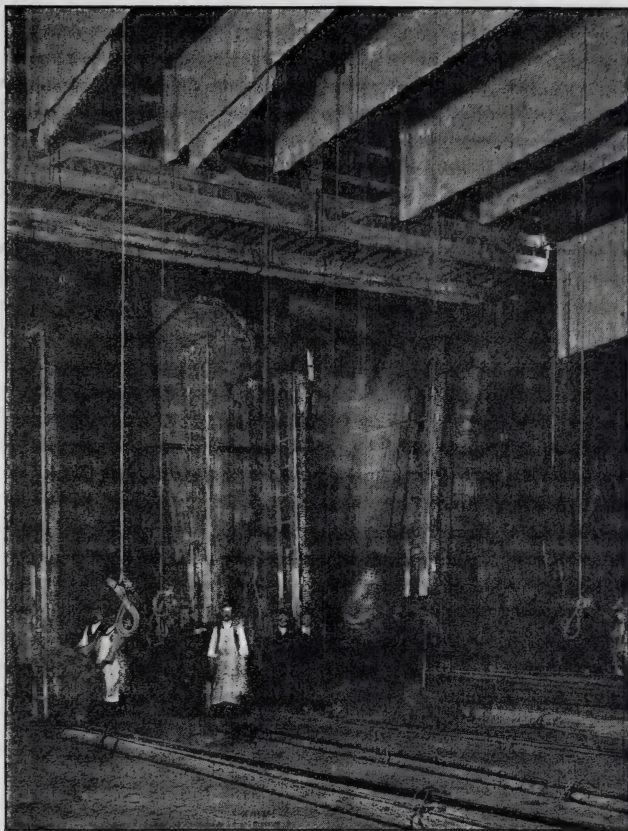
WOOD STAGES.

The English wood stage which we have before us is what I would term the most elementary form of stage mechanism that the world possesses, the mechanism, if we really take mechanism in its true sense, being almost *nil*, and the design and detail showing but the crudest forms of carpentry as practised two centuries ago. The example of an English stage of which I am showing you these drawings, is in every way typical of what exists but a few hundred yards from you at the moment, in this great centre of mechanical knowledge. It is a stage which is intended for the average theatre, which has a proscenium about 30 feet wide, and measures 60 feet between its main walls. It is not my purpose to go into technical detail, but you will observe from drawings that we have a series of so-called "bridges" and "sliders," four sets in all, in front of which is the usual "grave" trap and the two "star" traps through which the fairies and demons respectively appear. We see the stage floor with, below it, a so-called "mezzanine" and "cellar," whilst above it we have a pair of "fly galleries" and a "gridiron."

Now, in a few words, how does this stage work? First of all remember that the plan of the floor governs the general design of the stage, inasmuch as the series of "flies" or "wings" generally have to coincide with the position of the main "bridges," and that the whole of the constructional work is set out in connection with these openings. Imagine next, that from front to back, the stage is divided into a number of sections of about equal width, coinciding with the position of the "bridges," and that each section, which is defined in its extent by the position of the wings and borders above, has its approaches from each side by what are known as "entrances." The "wings" on this wooden stage are simply pushed on and off, sometimes with the aid of "grooves"

hung from the "flies," sometimes simply run on and screwed into position. The "borders," which belong to each pair of "wings" and backcloths, are hung from the "gridiron" and are pulled up or lowered by a simple system of "shafts," drums and windlasses worked from the "flies." If you want anything to appear from below, say to raise a "bridge" with some scenery or people, you find that the boarding moves off from right to left—"slider" fashion—to make room for the "bridge table"; and this table is also worked in the most elementary

we thus get the built-up scene in which everything is screwed together, and enormous combinations of staging, canvas, &c., known as "rostrums," "heavy sets," and the like. Clumsiness prevails in everything; and in the theatres, under the most enlightened management, the only variations we sometimes find are in the form of improved clips, or brackets or struts, or some other little contrivance to help join the various parts of a scene together; contrivances, by-the-bye, which, even in themselves, though improvements,



WOOD STAGE: COVENT GARDEN OPERA HOUSE, LONDON. GENERAL VIEW.

manner by the aid of drums, &c., from the mezzanine level. Each cloth, each "bridge," or each "wing," is moved separately by hand, or at times individual pieces may be coupled together to a limited extent. In other words, a scene is put together by dint of all manner of manual exertion, assisted by the roughest forms of roping and haulage imaginable. To obtain anything like good effects, the skeleton of the so-called machinery at the disposal of the scenic artist is, in fact, made but little use of now-a-days; nothing takes its place, and

would cause much amusement to the skilled mechanic.

But then, let us see what a stage of this description is like in one of our larger theatres, where the number of "bridges" may be eight or more and the roping becomes complicated. Here is a general view of the Covent Garden Theatre stage. I also show you the "flies" with their mass of roping, their endless canvasses, &c., and yet this photograph gives but a very flattering description of what the actual appearance of the place is. Here

is another view taken on the "gridiron." Similarly, you can see what the "flies" look like on the Drury Lane stage, and I take the opportunity to show you a photograph of part of the "gridiron" floor of this stage so that you may appreciate the reason of its name. Let us then take Her Majesty's Theatre, the latest of our London playhouses, and there we find that though there is a great improvement in the form of a flat stage in place of the sloping floor of old, all the makeshifts of a wooden stage as planned a hundred years ago are still to be found. In the auditorium of that theatre, as you well know, everything that modern science can give us has been tried, but behind the scenes—well, we had better not speak about it. And, yet, remember that on this stage we find some of the finest painted scenery that London has ever seen in Mr. Beerbohm Tree's production of "Julius Cæsar." If you were to step behind the curtain, however, and see how this enormous mass of canvass and wood is built up, you would not only appreciate the difficulties experienced in obtaining the effects which are obtained, but also what possibilities there would be on a modernly-equipped stage. And further, if you remember that though the canvasses are so beautifully painted we still have all the ridiculous anomalies of skies hanging like strips of linen, back walls blown to and fro and oscillating in every draught, you will marvel that where there was certainly a desire to give us the best that art could produce the science of to-day has been so entirely overlooked.

Here I should perhaps add a word to tell you that the wood stage of the Continent, though built up on very antediluvian lines, is yet a considerable improvement on our own. For we find there, even in the wooden stage, the "chariot" for moving the wings, and many other improvements. The planning of the stage floor also is far more practical, inasmuch as it gives the scenic artist greater opportunities.

WOOD-AND-IRON STAGE.

But let us next proceed to the wood-and-iron stage, which is occasionally of Continental origin, based on the more improved wood-stage mechanism, with the great difference, however, that where iron could take the place of wood, iron has been substituted.

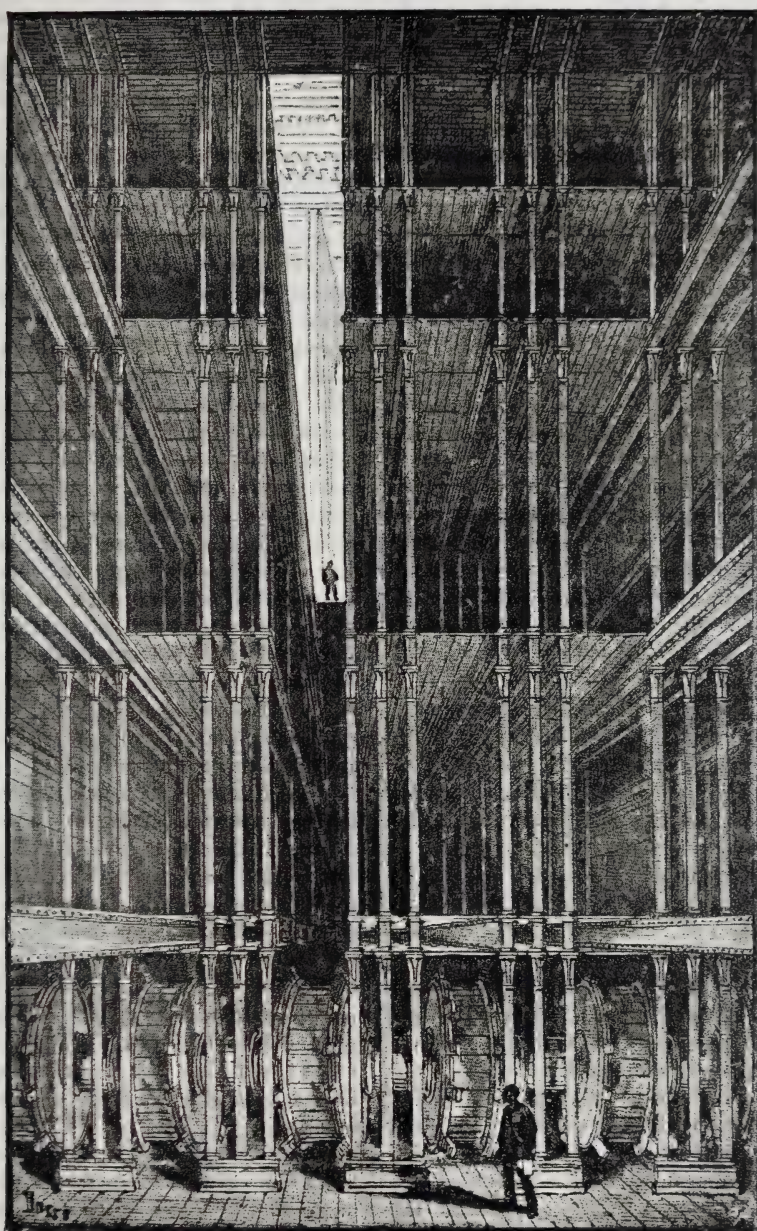
Of course the largest wood-and-iron stage which we have is that of the Paris Opera House, but here iron has been limited to the merely

constructional parts, such as the "gridiron," the "flies," the stage-floor and mezzanine levels. None of the actual appliances are of iron. Though every attempt was made by Charles Garnier, the architect, to obtain some practical improvements upon the stage when the Paris Opera House was built, he encountered so much prejudice that it became impossible for him to do what he intended. A plan here shows you the great extent of the Paris Opera House stage, and at the same time how the stage floor is divided up. From the section you will also see the main lines, but with the exception of the "chariot" already referred to, I think we may take it that all the principal parts are worked on the same lines as the Continental wood stage of old, and that there is nothing that is really modern in its design. To emphasise what I here say, I show you a view of the under-machinery, enormous, no doubt, in its dimensions, but a simple repetition of what you have seen on the English wood stage. Look at the cumbersome drums you will find in theatres built during the preceding century, and look at the "flies" with their enormous mass of roping. I cannot take you through other composite stages of this kind, such as the Rotterdam stage, the Schwerin stage, and others, all of which show some improvement on the wooden stage, and which in one form or another also show the adoption of iron construction. The importance of the Rotterdam stage among modern stages is due to the fact that it is a wood-and-iron stage of average dimensions, in which the former material predominates, the latter having only been employed for some main structural parts and for minor details. At the same time, there are distinct improvements, both in the arrangement of the upper-machinery and the under-machinery, as compared with that of the old wood stage. The old "drum and shaft" has been excluded for hoisting purposes, and the pulley takes its place on the gridiron level. The principal parts of the under-machinery have also been put together more systematically than before. At Schwerin the iron windlass and pulley takes the place of the wooden shaft and block. At Rotterdam the "chariots" which are employed are of particularly light construction. The greater lightness of everything on these stages is perhaps one of their most important features.

To only one other wood-and-iron stage would I here refer, because it gives me particular pleasure to point to an instance in which some attempt has been made to improve

matters in London. The stage of what is known as the "Palace Theatre of Varieties," but was formerly D'Oyly Carte's English Opera House, is the one of which I would

ments. This is the only instance that I can find in England where a stage has been planned with some regard to the needs of modern times.



WOOD AND IRON STAGE: NATIONAL OPERA HOUSE, PARIS. VIEW OF UNDER MACHINERY.

speak. The designer is Mr. Walter Dando, who has patented many of his improvements, and practically gives us a Continental wood-and-iron stage modified to suit English require-

IRON STAGES.

Let us now pass to the iron stage. My first example of an iron stage worked by manual power is that at Amsterdam, which shows an

exceptionally clear disposal of all the more important appliances of the earlier stage with material improvement. This Amsterdam example presents a very perfect piece of metal construction, in which the extended requirements of the more elementary stage have been fulfilled without unnecessary complication, and it also forms an excellent connecting link between an instance of a wood and iron stage, as at Schwerin, and the more advanced types of stage mechanism. The stage is self-contained, and surrounded by a thick wall, with only such openings in it as are necessary for the due performance of the "business" of the theatre. It is sufficiently lofty for its purpose, but, unfortunately, difficulties in the foundations did not allow the architect to give the "under-machinery" any considerable depth. Its design is based on the lines of the old German wood stage, and as an adaptation of a different material to the principles involved, the Amsterdam stage is in many respects a model example. It should be particularly noted that there has been no attempt at radical "Stage reform" in this case, but simply an endeavour to modernise and elaborate, under the special difficulty of want of depth for under-machinery. In this instance, manual labour has not been replaced by steam or hydraulics, and yet the design ranks high amongst the most modern examples of stage mechanism. The designer is Karl Lautenschlaeger, who also arranged the Schwerin wood and iron stage just referred to, and hence many of the same characteristics are observable in both.

Another example which I would class with the Amsterdam stage is that of the Christiania National Theatre, where the designer was Herr Rudolph, of Vienna.

Our next example is that of an iron stage worked by hydraulic power, which in its first form was designed by the "Asphaleia" syndicate. I would here refer you to a paper describing the advantages of the "Asphaleia" system which was read in this room some ten years ago, but I must at the same time say that much which was then promised by the promoters of this system has not been fulfilled, and that the "Asphaleia" stage, as designed 17 years back, to-day counts among the clumsiest first attempts at radical reform, and does not satisfy the modern demand for easy and straightforward working of the stage with due economy and lightness. As a matter of fact, the "Asphaleia" stage is a very unwieldy piece of mechanism. Nevertheless, we must

appreciate the serious attempt made at radical reform in 1881, and thank the "Asphaleia" syndicate for showing us what must avoid. The "Asphaleia" stage was a costly experiment, but it was certainly the pioneer of hydraulic stage mechanism.

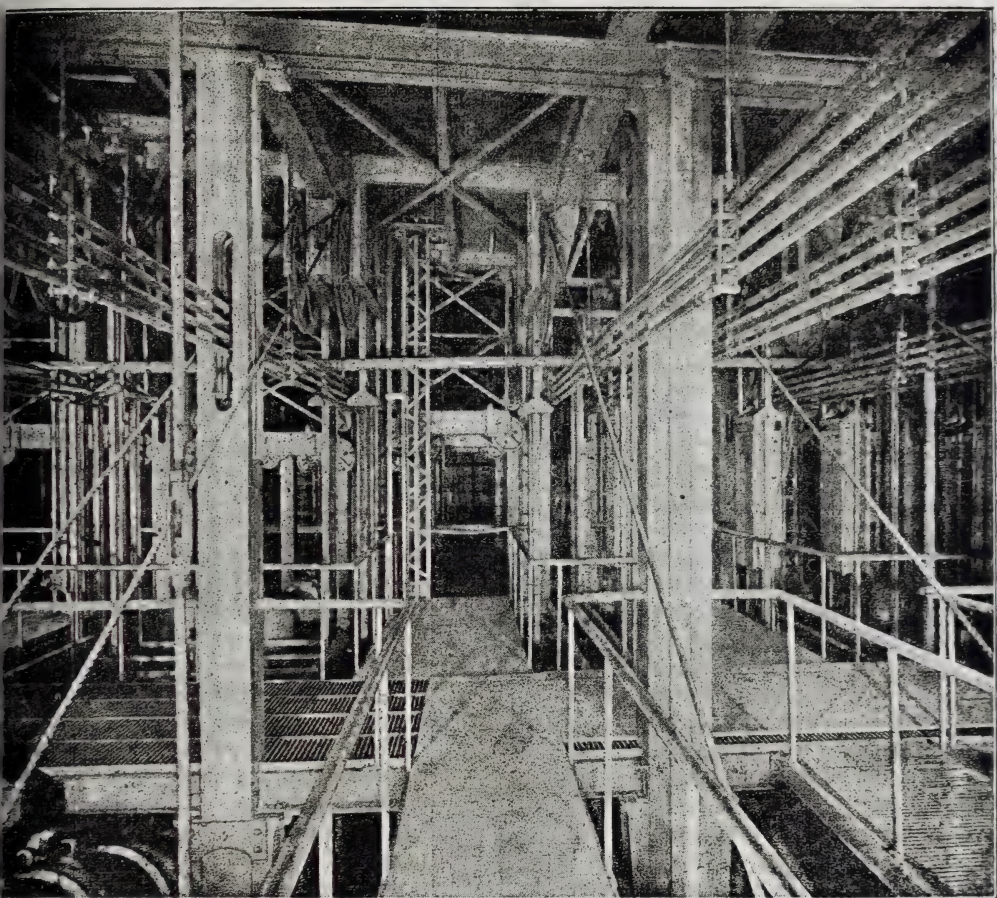
Summarised, the purpose of the "Asphaleia" syndicate was to construct everything of mechanism, in order to minimise the inflammability of the stage. Secondly, to make every part of the stage floor moveable, and, what is more, to allow a section of the floor to move above and below stage floor level at will, to enable the stage floor and sections of it to slope in any direction, and to give it the greatest possible elasticity. Next, the syndicate aimed at dispensing entirely with manual labour, and permitting everything to be worked from one point only and regulated by a single mechanism. The power to be employed both above and below the stage was hydraulic. It also had great ambitions as to scenic effect, and the dangling border, the angular wing and the straight back cloths, were very wisely done away with to make room for the curved horizontal and more artistic set pieces. The realisation of the artistic ideals put forward were, I am glad to say, found not only practicable but also highly effective, yet as regards the mechanical ideals—such as the idea of one man at keyboard working the whole of the stage machinery for a large opera—this was found neither economic nor reliable.

Among stages on which the "Asphaleia" system has been tried are those of Budapest, Halle, Prague, and Chicago. As to the Buda Pesth Opera House, the plan goes far to explain the divisions of the stage floor and to show how the flooring is supported on hydraulic rams which can be moved from the various levels. As I have said before, it is impossible for me to go into details in a paper of this description, but I am sure you will be able to appreciate this clever attempt at radical reform from which stage mechanism learnt so much.

This "Asphaleia" stage of 1881 was followed but a few years afterwards by the inauguration of the first hydraulic stage on suspended principles, and the example I would name is that of the great Hofburg Theatre at Vienna, which in many ways shows us the most perfect piece of stage mechanism worked by hydraulic power that the world has yet seen. It is true that the stage of the Hofburg Theatre was built regardless of expense, and therefore is not perhaps an example of economic stage mechanism

but it was the intention to make the construction on a model in every respect, and we should perhaps congratulate the promoters on their success in this direction. We have here only a limited extent an example of an attempt at radical reform; we have far more an example of practical reform. Thus we find that the principles of construction usually adopted on the foreign wooden stage as regards "flies," "back cloths," "chariots," &c., have been

Again, unfortunately, I cannot go into detail, and I have to limit myself to saying that, both in its entirety and in the most minute section of the equipment, perfection has here been very nearly reached; perhaps, however, I should add that I hold the example goes a little too far in the application of hydraulics to working the upper-machinery. The regular working of this upper-machinery, with the possibility of transferring the ropes on to hydraulic "jiggers"



AN IRON STAGE: VIENNA HOFBURG THEATRE UNDER MACHINERY.

retained, and that the modifications are limited to the lighter construction, fine metal work, and the application of indirect hydraulic power in lieu of manual labour. Similarly, though the stage floor is even more cut up and more elastic than the "Asphaleia" stage, the suspended system applied here, which allows the appliances to be worked by cables and pulleys, gives us a far more practical stage, in which there is no blocking of under-machinery by heavy vertical rams and the like.

the moment heavier loads have to be raised, would perhaps better fulfil the purposes of this theatre. The designer of this stage is Herr Brettschneider, of Vienna.

Now, whilst the "Asphaleia" stage showed us a system where the hydraulic ram was applied in its crudest form, and the Vienna Hofburg stage showed us the application of the suspended system, we have on the other hand the so-called Brandt system, applied by Herr Fritz Brandt in many of the leading

German institutions. In a few words, we might say that we here have the modern Continental wood stage modified and elaborated suitably for construction in the lightest forms of iron-work, and one which, though worked by labour for all ordinary purposes, allows for the application of hydraulics wherever larger effects become necessary. In regard to the stage floor in particular, I would point out that the large "bridges" are raised by a combination of one central ram and wires suspended from pulleys. In calling attention to Herr Brandt's system, I also take the opportunity of saying that I hold his appliances to be of the utmost importance in the annals of modern stage mechanism, for his work at the Berlin Court Theatres and elsewhere embodies much that is perfect, and will serve as a basis for further installations. Whilst the stages of Buda Pesth and Vienna have a more elaborate equipment, the application of hydraulics, as shown in Brandt's system, is nothing if not practical and economical, and shows us what can be done without having recourse to the extremist methods and appliances advocated by the original leaders of the stage reform movement. His stage appeals particularly to the manager who wishes to economise at the expense of his working staff without incurring too great an outlay of capital.

I now come to my last example. Having dealt with the iron stage worked by manual labour and several examples in which hydraulic power is applied, let me speak of an iron stage worked by electricity, but which at the same time embodies the principles of the turn-table, so well known on a small scale in the *tableaux vivants* we have had of late years. This is the latest development of stage mechanism. To speak briefly, we have here the floor in the form of one enormous frame, sub-divided into a number of "bridges," the frame being circular in shape, and running on wheels like the turn-table of the *tableaux vivants*. By an ingenious arrangement of exact sub-division the "bridges" in this frame can be worked by one set of rams, on the quarter round, the half round, and the three-quarter round. The electrical power used is both economical where power is generated in the theatre, and handy in this way, that the possibility of moving the appliances giving the necessary power is particularly easy. As to the system on which the turn-table is worked, I would only refer you to this large plan in which an opera set at Munich is clearly shown. The ease with which scenes can be set without long waits is re-

markable, and though we may not go to the extreme of setting three scenes ahead as is shown to be the case in the series of play before us, it is certainly particularly simple to be able to set two scenes ahead, for instance, in such short scenes as we find in Shakespeare and many of the modern operas. I have little doubt that the electro-motor will be the power of the future on the stage, though combined where the heavy weights of "under-machinery" are concerned, with hydraulic power. The electro-motor is particularly suitable for the "upper-machinery" and minor stage effects. For the "under-machinery," I still prefer the hydraulic power applied on the suspended system. One word of warning to those who may care to apply the electro-motor. Do not fall into the same error as the "Asphaleia" syndicate did when first applying hydraulics to the stage. Excessive employment of the electro-motor should be avoided as well as excessive centralisation. As to the turn-table, the contrivance is no doubt very ingenious; but its future lies only in those theatres which are devoted to grand opera, grand drama, and great spectacular effects. It should also not be forgotten that the turn-table become unwieldy if constructed to very large dimensions.

And now, before I close, a few words as to what has been done in England as far as the iron stage is concerned. I was fortunate in being able to point to Mr. Walter Dando's wood-and-iron stage as the one English example. It had, indeed, been originally intended that this wood-and-iron stage should be an iron one. But monetary reasons prevented this. This is the only proposal I have heard of for an iron stage, and that proposal, as you see, was not acted upon. Up to the present moment, I regret to say, there is not a single iron stage in the United Kingdom. While in many countries on the Continent they are rapidly becoming popular, we had not one instance where iron work and modern mechanical power has been systematically applied. And this curiously enough although a patent was taken out as early as 1875, dealing with hydraulic appliances, and tried, by Mr. Brown, of Edinburgh. The only other instance where English hydraulic appliances have been tried was in the Lyric Theatre, in which a set of small "bridges" were set up by Messrs. Bunnett and Clark. Lastly, however, we have at Drury Lane two very large lifts, measuring 40 feet by 7 feet each, built in Austria, designed on the "Asphaleia" prin-

CONCLUSION.

There is no doubt that before long considerable improvement will have to be made in the present condition of mechanism on the English stage, and already a marked tendency towards a practical issue of the movement of "Stage reform" is apparent. Quite a number of those engaged in theatrical enterprise are fully alive to the defects in the old wood stage, and I believe that were some influential manager to make a forward move regardless of the prejudice with which every new proposal in "Stageland" is greeted, many would follow his lead. It would undoubtedly require a man of conviction and determination, for there is nothing more difficult than stage management when, for instance, the stage carpenter, with antiquated notions, too frequently shows contempt for the lessee's innovations.

Such a step as that recently taken by Herbert Beerbohm Tree at Her Majesty's Theatre was of greater importance than is generally understood, for he introduced into this country for the first time a flat stage, and its use has simplified everything in connection with stage mechanism. The sloping stage has always been a hindrance to those who desired to adopt some mechanical power for the working or the handling of the scenery. The sloping stage always added to the first outlay for any innovation of this description. The flat stage had been tried and used successfully on the Continent for a considerable time, and in the United States it has for years been a popular improvement in every modern theatre. Nevertheless, the prejudice and ridicule with which Beerbohm Tree's idea of introducing the flat stage into London first met was almost astounding, and even after its advantages had been recognised there are many who would at once attribute any mishap, even of the most trivial kind, that might occur on the stage of Her Majesty's Theatre to the absence of the usual slope.

The late Sir Augustus Harris did much for stage improvements when he decided, contrary to the advice of many, to try hydraulic power on the Drury Lane stage; and his successor, Arthur Collins, is to be congratulated on the fact that he saw the ideas of his predecessor carried out, uses the various appliances placed at his disposal, and is at present considering further similar material improvement to the stage he now controls. And in connection with this it should not be forgotten that Drury Lane had to close its doors on account of an

accident in connection with the new installation, a fact that would have prevented a narrow-minded man from using such appliances again. Whilst many of the opposers of modern improvements rejoiced over the accident, the broader minded did not fail to remember that, not many years ago, the opening of a Drury Lane season had to be postponed on account of a not unsimilar collapse then, however, due to the clumsy appliances of the wood stage of old. And Mr. Collins also had the advantage of knowing what is being done elsewhere, and what economy means.

The descriptions I have given, and the opinions I have quoted will, I trust, be of some use to those who wish to follow the example that has already been set them by Beerbohm Tree, Augustus Harris, and Arthur Collins. I trust also that the descriptions may in some slight measure give an impetus to many who have not as yet considered the question of "Stage reform," but have, without much thought, utilised the methods and appliances which they have inherited from their ancestors and perhaps, at the most, are doing no more to improve them than grumble at their inefficiency. In any case these illustrations should give some insight into what progress has been made up to the present time in other countries in regard to stage mechanism.

I think that those who have listened to the address will agree that, though extreme measures may have been useful owing to the impetus given to the desire for improvement generally, the idea of their organisation often went too far, and that the outcome of their efforts, such as those which produced the "Asphaleia" stage, lacked those practical qualities which might have led to general adoption. On the other hand it will have been seen that those whose endeavours were directed solely towards the practical embodiment of their ideals, have materially assisted in the advancement of stage mechanism.

It is curious indeed that we have not been able to hold our own in work of this description as compared with Austria and Germany, and it is lamentable that in a country noted for its mechanical skill, an institution such as the theatre and its stage, which particularly require the attention of the engineer, should have been so lamentably neglected. To my mind it is not a question of expenditure; and I would emphasise this as I have so often encountered the argument that stage improvements and "state subsidies" must go hand in hand; for the foreign private theatre, a commercial con-

cern "on all fours" with similar institutions in this country, has also been able to show such advances. There is not the slightest doubt that for a small London theatre, a flat stage, with modern appliances and methods, would be economical, and the same may also be said of the large opera stage and the large variety stage. On the one hand manual labour may be retained, and on the other hydraulics may be introduced; but with good designing, there is not the slightest doubt that the capital which must be necessarily sunk will be a profitable investment, owing to the decrease in annual expenditure both for labour and repairs, and the absence of outlay for the adaptation of scenery.

Until within a few years ago many associated with the stage of this country considered that all improvements were questions of experiment, and that experiments would be far too expensive for the ordinary actor-manager. I cannot but repeat that I hold the experimental period to have passed, and that we are indebted to many of our foreign friends for lessons and examples which they have only learnt by great expenditure of labour and money.

In conclusion, I trust my treatment of so new a subject will not only be of practical utility to those already interested in the development of the modern stage, but, above all, will draw the attention of those who have not given much thought to the matter, to the great possibilities that exist for mounting our plays, not only in accordance with the facilities offered us in this era of progress, but also with less danger from fire, with less risk of accident to those employed, and with greater ease and economy. Why should we not take a leading position in stage equipment, banish the dangerous, unhealthy, impractical and expensive wood stages, and make room for something far better now that we are approaching the 20th century?

[A large number of drawings, photographs, and sketches of stages were shown on the screen and explained and criticised by Mr. Sachs. Reference was also made to a collection of drawings exhibited. Among the stages of which illustrations were shown were the following:—A typical wood stage; Drury Lane; Covent Garden; Her Majesty's; Court Theatre, Dresden; Court Opera House, Vienna; National Opera House, Paris; Municipal Theatre, Rotterdam; Palace Theatre, London; Court Theatre, Schwerin; Municipal Theatre, Amsterdam; National Theatre, Christiania; the "Asphaleia" system, Municipal Theatre, Halle; National Opera House, Buda Pesth; Hofburg Theatre, Vienna; Court Theatre, Berlin;

Court Opera House, Munich; special appliances at Drury Lane.]

DISCUSSION.

MR. GEORGE BERNARD SHAW said his experience of the theatre both as critic and author was not much concerned with stages such as Mr. Sachs had been describing. It was not easy in England to get much money expended in theatres unless people saw value for their money. For handsome dresses and things of that kind, where everybody could see the munificence of the management, many thousands of pounds would be spent to produce about sixpennyworth of effect, but if you wanted very elaborate machinery behind or beneath the stage, which instead of making the public think how extremely rich and liberal the manager was prevented them thinking about him at all, and simply made them think of the play, it was very hard to get the money for it. One of the difficulties of dealing with this question was that any stage-manager of experience would tell you that many of these things were never wanted in practice. He said that it was all very well to be able to set half a dozen scenes and twirl them round one after another when you wanted them, but he got on very well on the old system. The fact remained, however, that the absence of these facilities prevented authors writing plays in which they could be made use of. No author wanted his play made ridiculous, and if he had a great number of scenes, the patience of the audience was exhausted while the curtain was down and the scenes were being set, or when there was a front scene going on, to give the opportunity to set the next scene behind it. He had recently seen a representation of the tragedy of "Macbeth," which evidently had not been very well prepared, as there was apparently a good deal of difficulty behind the scenes. Those who had read or seen the play would remember what an effect was produced by the knocking at the gate at the conclusion of the murder scene, but on this occasion the nerves both of the actors and the audience were spared any shock of that kind, because there was such a hammering going on behind in preparing for the next scene, that the dramatic knocking at the gate passed quite unnoticed. Such things were very common, except at the very long-run theatres at the West-end, and even in them you often got most ridiculous effects. Everyone remembered the production of "Hamlet" by Mr. Forbes Robertson, a very delightful performance in many ways, and one very fine effect was devised by the scene painter in the ghost scene. As the ghost melted off, the scene gradually changed from the ramparts to the sea-shore. The horizon was all perfectly dark—at least, as dark as a stage ever was, and then you had the gradual breaking of the dawn. That was an excellent effect, but what had you to look at? There were a lot of things at the sides, and a decently painted cloth at the back, but the actual rocky coast itself was represented by a great expanse of wooden floor which destroyed all sense

of illusion, and rather from the influence of association led one to expect the *entrée* of a troupe of ballet dancers. He did not know if there was any remedy for that sort of thing. Again, there was the question of stage-lighting. A few years ago Mr. Alexander put on "The Prisoner of Zenda," and spared no expense over it. There was a scene in the second act in which you saw the sunset through a pine forest, which was a very pretty effect. In the front of the stage was a tree, which you could almost imagine to be real, and at the root of it was Mr. Alexander lying down just as a man would in a German forest, except that his clothes looked a little too new and smart. Now before becoming a dramatic critic he had had some experience as an art critic, and at the period, when one's wits had to be sharpened to see whether a man had really painted a picture in the open air or under the excellent north light of St. John's-wood; so the moment he looked at that scene, he saw that the light in which Mr. Alexander was lying was intolerably feeble and weak. When you had the strong effect of the sunset at the back, the foreground, to any person with an eye, was absolutely impossible. Unless you kept your eye rivetted on the back and ignored the front of the stage altogether, there was no possibility of believing it. Even at Bayreuth, where the clouds and all the meteorological effects were managed very well, in the final scene of "The Rheingold," where there was a rainbow at the back of the stage, and the gods went up across the rainbow bridge to the castle, the whole effect depended on the eyes of the audience being rivetted on the rainbow; otherwise even the gods looked dull and shabby. Of course the audience could never see more than one thing at a time, if they could see that, but the tolerance of audiences was constantly declining; he used to look at things in his youth without turning a hair, which nobody would stand now, and the question was how to keep up with the opening of the eyes of the public. Coming to the electric revolving stage, on which you could set a great many scenes which should appear in rapid succession, he believed it would add immensely to the effect of melodramatic plays of rapid action, such as were found in the Elizabethan drama where you had a story rapidly told in a succession of short scenes, rapidly changing. He had written a play, which had proved fairly successful in America, in which he was in something of a difficulty because in the third act he wanted to present three scenes successively. He had not gone to America to see it acted, but he knew very well what it was like. The first scene was a front scene, with a cloth hanging down representing nothing in particular, squeezing the two actors right down to the footlights, and the carpenters behind almost jogging their elbows so that they had to play very hard to hold the attention of the audience. Then the cloth would be rolled up and the actors could get a little further back, and there was a large and handsome judge's chair which concealed behind

it a gallows, which came into operation in the third scene. He should much prefer to have a revolving stage on which you could have three decent sets which would change rapidly, because it would be much better for the play. It would afford much more scope for the author if you could have twenty-six or twenty-seven scenes to follow one another straight on but with a revolving stage, when the first scene had been disposed of, the set could be changed, and so on continually, and in that way you might have such a development of plays of quick action, that before very long one might actually arrive at a state of things when a theatre would really be a place of amusement.

Mr. J. MULHOLLAND said everyone would agree that in England we were far behind the continent in many stage requirements, but in watching the developments which had taken place there he saw several reasons why the same things could not be expected here in the near future. The conditions were entirely different. On the continent there was State or municipal aid for the manager who endeavoured to produce plays artistically; here there was nothing of the kind. Theatre building took its initiative in the speculative architect, who, having found a suitable site, next found a speculative capitalist, who looked simply for a good return on his investment, and always had before his eyes the authorities at Spring-gardens, who might step in at any moment and require an expenditure of £3,000 or £4,000 on matters which they had not before deemed necessary. For theatres in London, the improvements Mr. Sachs had described were hardly required, and the other class of theatres were the suburban and provincial houses, which were confined to six-night runs of plays sent on tour already equipped with most of their scenery; and these theatres, even if they had these appliances, could not use them because of the stage-manager who travelled with the scenery of the plays, and was a most appalling person. If you suggested anything to him as an improvement he would not hear of it. Some time ago he built in one of his theatres a thunder apparatus—a series of traps and grooves down which cannon balls were rolled, producing an excellent imitation of thunder, far superior to the old-fashioned thunder, which resulted from shaking a sheet of iron held at one corner, but when he suggested that this apparatus should be used on one occasion, the travelling-manager, who had brought his own tea-tray with him, would not hear of it. That sort of thing prevented the introduction of many of the improvements which Mr. Sachs recommended. He must also say that in some cases plays were overloaded with scenery; there was merely a streamlet of play meandering through a meadow of scenic effect. Referring to the Hamlet scene, of which Mr. Shaw had spoken, the daybreak struck him as being excellently worked, but it really detracted to his mind from the effectiveness of the

play, because, instead of listening to the words of Shakespeare, he could not keep his eyes and mind off the gradually-brightening dawn. Some years ago he remembered seeing a play in which the moon was made to rise, and it rose fairly smoothly; but still the moon worried him; it interfered with the language of the dramatist and the acting of the performers. Some time ago he saw a play at the old Haymarket, when considerable alterations were made to admit of a shipwreck; it was not the be-all and end-all of the scene; it was not dragged in for the sake of effect, but was quite incidental to the story. The winds howled very respectably, the ship rocked, and the waves roared and tumbled about in a very satisfactory manner; but while all that was going on he did not hear more than one word in ten of the dialogue, and therefore he considered the scene a mistake. The scenery of a play should only be the background, the environment: it should not be so pronounced and aggressive as to interfere in any way with the action of the play, which, after all, was "the thing." He had seen some very magnificent productions at leading theatres, where the very magnificence of the scenery detracted from the true artistic effect of the play. At the same time, he did not mean to say that there was no room for improvement in stage machinery. On the contrary, he held there was a good opening for any one who would build a theatre possessing some of these modern appliances, and when one had shown the way no doubt others would follow.

Mr. ALFRED MOUL said he hoped some millionaire or philanthropist would come forward and carry out Mr. Sachs' suggestions. By the courtesy of the Buda Pest officials, he was allowed some time ago to examine the stage there, and his first thought on seeing it was, if he had such a stage what could he not do? But before he had finished his examination he felt glad that he had not got it, and thought that if he had he should not know what to do. When he came back and saw the resources of the stage for which he had been responsible for some years, he saw there was a great deal to be done, but he reflected that it would cost so much money as to preclude any chance of a dividend, and so prudently refrained from suggesting anything of the kind to his directors. That was the great secret of the tardy progress in stage matters; the £5 note which Mr. Sachs rather glibly alluded to went very quickly, and gave very little result. He found that the stage at Buda Pest cost some £60,000, a sum which no board of directors or actor-manager would care to invest without a very definite prospect of deriving a substantial benefit, and he did not think from what he saw at Buda Pest that there was any great result, even in an artistic sense, achieved; he came away convinced that he could put a much more artistic production on the Alhambra stage than anything he saw there. At the same time, he was quite conscious that we were much behind in England, and

hoped the philanthropist or millionaire, who had been referred to, would speedily be found.

Mr. W. DANDO thought Mr. Sachs could not mean to seriously suggest that the first effort at really artistic productions was made about 20 years ago, because many years before that there were exceedingly beautiful and artistic scenes painted by the elder Telbin, the brothers Green, William Beverley, and others, and there were many fine scenes in store at Covent Garden, which it would be difficult to beat even by the most modern German artists. He had seen Prof. Herkomer's stage at Bushey and some of his sets, but it must be remembered that many of these took several months in building upon the stage, and it was impossible to move them, so that the system adopted there was utterly inapplicable to an ordinary stage. Again, the stage was so arranged that you could not see them; there was no orchestra and no footlights, in fact, there was no stage to speak of, it was not much more than a toy stage, and the methods adopted could never be employed on a large scale. He had had something to do with the Palace Theatre stage, and Sir A. Sullivan and Mr. D'Oyley Carte made many experiments there with the view of doing away with the footlights, but it was absolutely impossible. The hydraulic system had been partially adopted both at the Lyric Theatre and Drury Lane and also in the provinces, but he believed the mistake was often made of not having sufficiently skilled men to work the apparatus. In one of the suburban theatres where he was superintending the production of a piece for Mr. Buchanan, he wanted two or three little things hung from the gridiron, but found there was no provision for anything but the most absolutely necessary appliances, and on inquiry he ascertained that the whole cost of the stage, including drums and ropes, was about £160, yet the theatre was floated for £50,000 or £60,000.

Mr. JOHN LEIGHTON, said he was afraid the English people would never be satisfied to do as they did at the Theatre Français in Paris, without an orchestra, and with very few scenes, but with first-class acting.

The CHAIRMAN, in proposing a vote of thanks to Mr. Sachs, said they had already had the opinions of experts on this question; he could only speak as an old playgoer, dating back to 1857 or thereabouts, and having seen the revivals of the Shakesperian plays at the Princesses' by Charles Kean. He was bound to say that he thought very gigantic strides had been made in the way in which the author's ideas were illustrated on the stage. He had a strong objection to the highly-sensational productions where the whole object to be achieved seemed to be to show how people could eat a luncheon on the stage in the way they did in ordinary life. He remembered his old friend, Palgrave Simpson, once playing in a piece called "The Frozen Deep," in which he

had to come in and say he was starving; unfortunately, as he did so, he looked up and saw a ham and pickles painted on the side of the scene, which somewhat disconcerted him, as it was flagrantly inconsistent with his statement. That sort of thing did happen a good deal in the old days, but he hoped it was now quite a thing of the past. He feared he should not live to see introduced all that Mr. Sachs recommended, but he was sure that the valuable suggestions he had made would be marked by those interested, and that to some extent, at least, good results would follow.

The vote of thanks having been passed unanimously,

Mr. SACHS, in reply, said there was no doubt the Buda Pesth stage was much too elaborate, which was probably the reason it cost so large a sum. With regard to hydraulic machinery, he believed Mr. Dando had hit the right nail on the head in suggesting that any occasional failure in action had been due to want of skill in the operators, not to any defect in the machinery itself.

Obituary.

T. R. TUFNELL.—Mr. John Robert Tufnell, J.P., Chairman of the Royal Mail Steam Packet Company, whose death occurred at Ouchy, Switzerland, on the 1st inst., was elected a member of the Society of Arts in 1870. He was auditor in 1871, treasurer in 1872-73, and member of the Council 1874-77. Mr. Tufnell took much interest in the work of the Society, and presided at the evening meetings on several occasions. He was announced to read a paper before the Foreign and Colonial Section on "The Sugar Industry in the West Indies" on the 5th of the present month; but the unfortunate accident, which eventually caused his death, made it necessary to postpone this, and his death actually occurred before the date arranged for the meeting.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock:—

APRIL 27.—"Photography and Colour Printing." By CAPT. W. DE W. ABNEY, C.B. R. BRUDENELL CARTER, F.R.C.S., will preside.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock:—

APRIL 28.—"India and Currency." By SIR EDWARD SASSOON, Bart. SIR DAVID M. BARBOUR, K.C.S.I. (late Financial Member of the Viceroy's Council).

APPLIED ART SECTION.

Tuesday evening, at 8 o'clock:—

MAY 3.—"Senefelder and the Centenary of Lithography, 1798-1898." By JOSEPH PENNELL.

* * Sir William Blake Richmond's paper on "The Importance of Craftsmanship," announced for Tuesday, 26th inst., is unavoidably postponed.

CANTOR LECTURES.

Monday Evenings, at Eight o'clock:—

DR. D. MORRIS, C.M.G., "Sources of Commercial India Rubber." Lecture II.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, APRIL 25... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Dr. D. Morris, "Sources of Commercial India Rubber." (Lecture II.)

Scottish Society of Arts, 117, George-street, Edinburgh, 8 p.m. Dr. R. Craig MacLagan, "Highland Dyeing and Colourings of Native-made Tartans."

Geographical, University of London, Burlington-gardens, W., 8½ p.m. The Prince of Monaco, "Investigations in the Atlantic."

Actuaries, Staples-inn-hall, Holborn, 7 p.m.

Camera Club, Charing-cross-road, W.C., 8½ p.m. Dr. Norman Collie, "The Canadian Rocky Mountains."

Medical, 11, Chandos-street, W., 8½ p.m.

TUESDAY, APRIL 26... Royal Institution, Albemarle-street, W., 3 p.m. Mr. T. C. Gotch, "Phases of Art: Past and Present." (Lecture II.)

Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Annual General Meeting.

Photographic, 12, Hanover-square, W., 8 p.m.

Anthropological, 3, Hanover-square, W., 8½ p.m.

WEDNESDAY, APRIL 27... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Captain W. de W. Abney, "Photography and Colour Printing."

Japan Society, 20, Hanover-square, W., 8½ p.m. Mr. Yoshitaro Yamashita, "The Influence of Buddhism and Shintoism."

United Service Institution, Whitehall, S.W., 3½ p.m. Colonel Boyes, "Compulsory Service for Home Defence."

Royal Society of Literature, 20, Hanover-square, W., 4½ p.m. Annual Meeting.

Mechanical Engineers, 25, Great George-street, S.W., 7½ p.m. Presidential Address.

THURSDAY, APRIL 28... SOCIETY OF ARTS, John-street, Adelphi, W.C., 4½ p.m. (Indian Section.) Sir Edward Sassoon, "India and Her Currency."

Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Rev. Canon Ainger, "Some Leaders in the Poetic Revival of 1760-1820." (Lecture II.)

Camera Club, Charing-cross-road, W.C., 8½ p.m. Mr. Alfred East, "Landscape Photography from an Artist's Point of View."

FRIDAY, APRIL 29... Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Prof. Andrew Gray, "Magneto-Optic Rotation and its Explanation by a Gyrostatic Medium."

Clinical, 20, Hanover-square, W., 8½ p.m.

Mechanical Engineers, 25, Great George-street, S.W., 7½ p.m. 1. Discussion on Report of Gas-engine Research Committee. 2. Mr. Sidney Tebbutt, "Steam Laundry Machinery."

SATURDAY, APRIL 30... Royal Institution, Albemarle-street, W., 3 p.m. Sir Walter Parratt, "Programm Music." (Lecture II.)

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FRIDAY, APRIL 29, 1898.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****CANTOR LECTURES.**

On Monday evening, 25th inst., Dr. D. MORRIS, C.M.G., delivered the second and last lecture of his course on "The Sources of Commercial India-rubber."

The lectures were illustrated by a series of lantern slides and by specimens of india-rubber in the natural state and in the various stages of manufacture, kindly lent by the India-rubber, Gutta-percha, and Telegraph Works Company, Silvertown, by various objects and instruments used in the manufacture, lent by Dr. Obach, and by plants and numerous specimens from Kew Gardens. On the motion of the Chairman a vote of thanks to the lecturer for his interesting lectures was passed.

The lectures will be printed in the *Journal* during the summer recess.

INDIAN SECTION.

Thursday, April 28; Sir DAVID M. BARBOUR, K.C.S.I., in the chair.

The paper read was "India and her Currency," by Sir Edward Sassoon, Bart.

The paper, with a report of the discussion, will be published in a future number of the *Journal*.

Proceedings of the Society.**INDIAN SECTION.**

Thursday, April 21; J. M. MACLEAN, M.P., in the chair.

The paper read was—

RECENT RAILWAY POLICY IN INDIA.

BY HORACE BELL, M.Inst.C.E.

In venturing to read a paper on this subject, I am aware that it is one that has already been dealt with in previous contributions and discussions before this Society, and comparatively recently in most able and comprehensive papers by Mr. J. M. Maclean in 1884 and by Sir Juland Danvers and Sir Theodore Hope, in 1889 and 1890. The subject is, however, one of such great importance, both to India and to this country, that it seems to be advisable, if not indeed necessary, that it should be brought forward again from time to time, and that we should review our position in the altering lights of opinion, and of finance. My justification for addressing you on this matter is, that I have been engaged in India for the best years of my life in the construction and administration of railways, and in 1894 published a book* in which I gave a brief account of the railway policy of the Government of India up to that time.

We may date the commencement of our Indian railway system from the year 1850. Its birth was fitly preceded by negotiations extending over about six years, during which a sort of quadrangular duel was carried on between the Government of India, the Court of Directors of the East India Company, the Board of Control, and the promoters of the various projects then put forward for consideration. We were at that time, at home, still under the influence of the widespread agitation and speculative fever which characterised the "railway mania" of 1845, of the effects of which we are only now fully sensible. The money that was then, and for many years after, recklessly and unrestrainedly flung away on the financing and construction of our railways here, is now bearing fruit in fair dividends, but at the cost of rates and fares that weight us very heavily in our competition with foreign produce and manufactures. Fortunately for India, we had then a statesman at the helm, Lord Dalhousie, whose exceptional firmness and ability, joined to some experience of railways in England, enabled him to save our Indian railways from being exploited in the way that had been done at home. He held that railways should not be regarded as merely private undertakings, but as national works, and that the State might, and indeed should, exercise "a stringent and salutary control"

* "Railway Policy in India."—Livington.

over them, both in the interests of the State and of the public. This important point he held to and carried, and it has remained as the foundation and salient feature of railway policy in India. As to the agency to be employed for carrying out and working the railways, Lord Dalhousie held that it was advisable to make them over to joint stock companies, under the control and supervision of the Government. The companies were to be guaranteed a return of 5 per cent. on their capital outlay, and when the lines earned a surplus over this figure, the advances towards making it up, which might previously have to be made by the Government, were to be gradually repaid. On this basis, a great scheme of trunk lines was laid out, and placed in the hands of six great concerns, viz., the East Indian, the Great Indian Peninsula, the Madras, the Bombay and Baroda, the Sind, Punjab and Delhi, and the Eastern Bengal Railway Companies, all on a gauge of $5\frac{1}{2}$ feet. This system was adhered to without material change until 1869, and on the whole the results must be allowed to have fairly fulfilled the expectations of the Government. There was rarely any difficulty as to the supply of funds; the anticipated complications and friction with the staff of the companies were only experienced at first, and the works went on steadily, even during the mutiny of 1857-58, a lesson which has been seemingly forgotten in later years.

Towards the end of 1863, proposals for the formation of new undertakings were before Government. In all of these there was a stipulation for assistance, or guarantee, in some form or other, and it became necessary to reconsider the position, the result of which was the launching of the Indian Branch Railway Company, on the basis of a subsidy of 1,000 rupees per mile per annum for each mile open, with an additional allowance for each large bridge, the requisite land being given free. This, however, did not turn out well; only about £200,000 being raised out of a proposed capital of £2,000,000, and a demand was then made for the 5 per cent. guarantee instead of the subsidy. This was at first refused, but was eventually granted after lengthy negotiation, and on the condition that surplus profits were to be shared with the Government. But this case may be considered to have been the starting point of an entirely new policy.

The Government of India was then under Lord Lawrence, and both he and his advisers had made up their minds that the further

application of the agency of companies was undesirable. They held that their operations might attain to such dimensions as might lead to inconvenience, or even become "dangerous," while at the same time proportionately inefficient; that it was necessary to fix a limit to the cost per mile on which a guarantee should be given; and that the Government should have more direct power over the servants of the companies, even to the extent of suspension or dismissal; and finally that, for political reasons, it was desirable that the Government should by degrees obtain possession of all the railways. They ended by recommending that all future railway extension should be carried out by the direct agency of the Government, and this was at length agreed to by the Home Government, with a proviso that a definite annual sum should be devoted to this purpose, which was then fixed at £2,000,000 sterling. It need scarcely be said that this was a very important change of policy, the more so as it also led to the introduction of a second gauge—the metre; but if the grounds upon which the decision was then based are fairly considered, it must be allowed that they were of great weight. The guaranteed lines had been costly, and so far unremunerative. The immense export trade, which has since grown up, was as yet in its infancy, and there seemed to be no evidence to justify any expectation of the prosperity which since then has come both to the railways and the people; the payments towards meeting the guaranteed interest were, moreover, a serious drag on the finances. It was then reasonable to assert that India could no longer afford to undertake further railway extension on the same scale as to cost per mile, especially as the areas to be served in the future were, or seemed to be, less likely to be profitable than those already dealt with. Added to these considerations was a weighty one in the fact that the Government had at this time a large establishment of engineers in the Public Works Department, for which it was absolutely necessary to provide a steady source of employment. Being then one of this body, I can well remember our enthusiastic support of this new departure. We rejoiced in a decision which placed at our disposal a new and vast field for our energies. We were to have opportunities of showing the companies how to make and work railways cheaply and profitably, and we looked forward to the probability of all the railways eventually becoming State property, and their being

carried on by a vast State organisation, offering attractive vistas of patronage, preferment, and pension. The new policy was almost as cordially received by other departments of the Government, both civil and military. They too probably had their axes to grind. Some of them had pet schemes which they would now be able to press on the Government with greater chance of success, while many doubtless gave thought to sons or nephews, *in esse* or *in posse*, for which a new department would or might provide an opening. There appeared to be no possible objection to the new system, and on the top of it all was the crowning advantage in the State being able to put all profits into its own pocket instead of into those of rapacious shareholders in London. I will say no more for the present on the matter save this, that what I think was not then realised was the effect that this change might have in the future in the attitude of the Government towards private enterprise.

A commencement was made under the new system in 1869, the construction of metre gauge lines being put in hand by Government engineers. The companies' lines were left to be completed by them, but no new proposals were allowed. This went on for about 12 or 13 years, and as far as construction was concerned, the work and the saving in cost, allowing for reduction in gauge, compared very favourably with the companies' lines. The weak point at first was in the working. There were too many "new brooms," too much zeal in some places, and too little in others; while there was, I think, a tendency to rashly assume that a Government officer could work a railway as well as he could anything else, or as any other man. We had to learn a good deal, and necessarily at the expense of the State and the public, although that consideration did not perhaps disturb us as much as it ought to have done. But the evil, which State administration of railways then suffered from, as indeed it does still, lay in the constant change of *personnel*, due to claims for preferment in a large service necessitating the movements of officers from important posts to other and distant localities. Added to this was an evil equally fatal in the attempt to control nearly every action of a manager from the headquarters of Government. In this latter respect matters have much improved of late years.

In 1874, and again in 1879, very serious and widespread famines occurred in India, which, in spite of lavish expenditure of money, and

heroic effort on the part of the servants of Government, involved a terrible loss of human life, and of live stock. It became clear, after exhaustive enquiry, that the only effective method of meeting such calamities in future was by giving railway communication to the tracts which had been most affected, and generally to enter on a large and well-considered scheme of famine protective railways throughout the country. This being settled, it was equally clear that under the restrictions then placed upon the Government of India as to borrowing powers, and in view of the limited amount that could be spared from revenue, it would be impossible to fulfil any such scheme with sufficient rapidity. A modification of the policy of 1869-70 seemed inevitable; but this took a very long time to determine. From 1880 until 1884 the Government of India was engaged in a continuous correspondence on the subject with the Secretary of State, and privileged as I have been to see and peruse the papers, I cannot but record my impression of their profound interest, and the evidence they afford of great ability, and patient and single-minded statesmanship. Among the combatants in this intellectual struggle are to be found names of men who have pre-eminently left their mark on the financial and the railway policy of India, such as Lord Ripon, Sir Theodore Hope, Sir Evelyn Baring (now Lord Cromer), Sir Auckland Colvin, and others. In the end the elements of a new policy were formulated in a shape which was somewhat as follows. The agency of companies was to be re-introduced for the construction of new lines, and for the working of railways belonging to the State. The assistance to such companies was to take the form of a "limited guarantee," a term, by the way, of which there is no very clear definition, and of the free grant of land; surplus profits over and above the figure of the guarantee were to be divided with the Government; the control of rates and fares was to rest with the State, and equitable terms were to be made in all contracts for the purchase of such lines, as public property, after a certain period. The lines to be made over to companies were to be such as were considered likely to be profitable, either at the outset, or soon after the lines were opened through, the term then used for these being "productive" lines. On the other hand, the direct action of the State was to be restricted. It was to be confined to the construction of lines which were not likely to be immediately or directly profitable, but which might, nevertheless, be urgently needed,

either for famine protection, or for military reasons. No definite policy seems to have been then, nor indeed has been since, formulated as to the agency to be adopted for the working of the then existing State railways, or of those which would become the property of the State on the exercise of the purchase clause in the companies' contracts. This part of the programme was perhaps left advisedly in a nebulous condition, either with the idea that any premature declaration on this point would be impolitic, or that it was generally desirable to have both the companies and the State working in emulation at the same time. Signs were, however, not then wanting of the existence of a feeling that the action of the State in this, and in other directions, had gone too far, and should be curtailed. This feeling was indicated in the Press, and very forcibly in Sir Evelyn Baring's financial statement of March 1881, a public statement which may be supposed to have in some degree reflected the views of the Government at the time. He admitted that while railways were monopolies, this by no means implied that they should be in the hands of the State, or be regarded as a direct source of State profit. The State should exercise so much supervision over the railways as was necessary for the protection of the interests of the public; should have the right of inspection, of regulating tariffs, and of purchase after certain periods; but that, when these and some other conditions had been made, the necessity for State interference ceased. As to possible loss of revenue, it was held that if the profits of a railway "were left to fructify in the pockets of the people," they would be more advantageously employed than if paid into the State Treasury. In short, that the State should be content with the indirect profits of a railway system. As we learn from Sir Theodore Hope's paper, similar, or somewhat similar, views had been expressed by Lord Salisbury in 1877, and by Lord Hartington (now Duke of Devonshire) in 1882. It may also be stated that the same views were strongly expressed by Sir Andrew Clark at the termination of his service as Minister for Public Works in 1880.

The new departure, which we may date as starting from 1881, can be regarded as the beginning of recent railway policy, and implied the complete abandonment of the policy of 1869-70. The urgent need of enlisting the aid of private enterprise was acknowledged by both the Government of India and the Home Government, and on the basis of "a safe and

reasonable guarantee." In 1881 and 1882 three companies had been formed, viz., the Bengal Central, the Bengal and North-Western, and the Rohilkund-Kumaon, without any guarantee at all, but the schemes were then small ones, and there appeared to be no likelihood of any considerable progress on this basis. The next step was the grant of a guarantee of $3\frac{1}{2}$ per cent. in sterling on the capital of the Southern Mahratta Railway Company, and on very advantageous terms to the company as regards division of receipts; but an entirely new and important feature was introduced into the contract in that the company was to be regarded as merely an agency for raising the money for the line for the Government—in fact, the company raised a loan for Government on a guarantee of interest; the line belonged to the State, and the company was to work it, practically on lease, for a term of years under definite control. The lines to be constructed by the company were regarded as essentially necessary for famine protection, and as they were not expected to be remunerative for many years, the undertaking may be said to have been a State operation conducted through the agency of a company. This was the first and the prototype of the "assisted" companies, the assistance, however, taking the very substantial and attractive form of a sterling guarantee, somewhat above the English market rate, together with a prospective share of surplus profits and free grant of land. The word "assisted" seems, in fact, to have been invented in order to screen the fact that such companies were guaranteed. In this category may be included subsequently formed companies under the titles of the Indian Midland and the Bengal Nagpore Railways. In all of these cases the Government could have raised the requisite capital itself in London and made it over to these companies on far easier terms, but this course was barred by the restriction of its annual borrowing powers by the decision of a House of Commons Committee. What the Government was then debarred from doing they have been enabled to do since, the most recent procedure being for a company to raise a comparatively small proportion of the required capital, and for the Government to raise the remainder and make it over for disbursement to the company, on conditions under which the State becomes an active co-partner and co-sharer in the undertaking.

But whether the new policy was or was not

unnecessarily liberal from our present point of view, it was one which rapidly and satisfactorily yielded notable results. It gave us the lines I have already mentioned, which form a very important part of the famine protective railways, and, in addition, a now very useful and prosperous undertaking, the South Indian Railway. To this policy we may also perhaps attribute the *renaissance* of the standard gauge, and the discovery that, if due economy was studied in first cost, the extension of Indian railways, even on this gauge, could be made a profitable investment. The progress between the years 1881 and 1887 showed a far larger annual average of completed mileage than had ever been exhibited previously. Within this period over 6,000 miles of line were added to the Indian railway system, and under financial conditions which were, on the whole, and under the circumstances, equally satisfactory to the State and to investors. It was not to be expected that this rate of progress could be long continued, if for no other reason than that the important blanks on the map were being filled up; but apart from this, the financial difficulties of the Government, due to the cost of frontier defences and to the continued fall in the sterling exchange value of the rupee, had by 1889-90 become very serious. It seemed no longer possible to increase the sterling obligations of the State by granting sterling guarantees, and that, unless some other means could be found for attracting English capital, the future of railway extension would have to depend on what could be effected from the annual State loan for public works. It was at this time that the promoters of the Delhi-Umballa-Kalka Railway came forward. They offered to find the requisite capital for the line without any guarantee, on the understanding that it should be worked by the Government at 50 per cent. of its gross receipts. The scheme promised well, but it was the only offer then made on such conditions, and between 1889 and 1892 the progress of railway extension was so restricted that it seemed likely to be soon stopped altogether. Some hope of relief was engendered by proposals made to construct the Assam-Bengal Railway on capital raised on grants of lands and minerals. This, however, fell through, but in the end, in 1892, to the astonishment of the public, and, perhaps still more, of the Government of India, this line, which was not urgently wanted, and which for two-thirds of its length cannot for very many years be of any practical value to

the province, was sanctioned by the Secretary of State under a sterling guarantee to the company of $3\frac{1}{2}$ per cent. on their capital during construction, and, thereafter, 3 per cent. until the determination of the contract. Of the capital required for the line, the company, however, found only £1,500,000, the rest, which may now be perhaps £6,000,000 or £8,000,000 more, has to be found by the Government, and it must seem very unlikely that 2 per cent. will ever be earned on it. The decision of the Home Government in this case must be regarded as having been a severe blow to the position taken by the Government of India, viz., to grant assistance to outside capital in no other way than by rupee guarantee on rupee capital outlay. It, indeed, made this position untenable in dealing with new proposals, and intensified the feeling of doubt as to the good faith of the Government.

Towards the end of 1893, a fresh attempt was made to attract capital on a rupee basis, for the construction of branch lines, the essential features of the new terms being that such lines would be worked by the State for not more than 50 per cent. of gross earnings, including the provision of rolling stock, and that a rebate would be given by the parent line on traffic interchanged with it, so as to make up, or towards making up, a return on the approved capital of 4 per cent. The exchange value of the rupee was then approaching its lowest figure, as in June 1894 it reached the depth of 1s. 0 $\frac{3}{4}$ d., and there then seemed to be no grounds for expecting that this was the limit, or that even this figure would have any stability in the near future. Added to this, was the obvious difficulty of estimating the value of the rebate, or the probable receipts from local traffic. These new terms were not favourably received by the public; they did not, in fact, appear to provide, as the notification of the Government put it, a real "additional encouragement for the investment of private capital," more particularly as it was plainly stated that it was not the intention of the Government to grant these terms as a rule, but that each project would be treated on its merits. On the other hand, there was an apparently important and suggestive proviso to the effect that no concession would be given to a proposal which did not show reasonable prospects of financial success. The effect of this condition was, however, unfortunately marred in a memorandum for the guidance of promoters, at the end of which it was stated that, while the Government would place all the

information it had regarding such proposals at the disposal of promoters, it would accept no responsibility whatever as regards its accuracy. It was as if a man were to try to raise money on a gold mine, and should say "I believe its a good thing, but I can't undertake that the documents I show you are worth anything." Subsequently, however, in 1896 these terms were somewhat improved, while the closing of the mints seemed to promise grounds for the hope that exchange would eventually obtain some amount of stability. Anyhow, proposals of considerable importance then came forward, and there appeared to be good promise of the fulfilment of the intentions of the Government, or, perhaps I should say, of their apparent intentions. The manifest flaw in this new system was that it must lead to the growth of a large number of small companies subsidiary to but yet in a position of more or less independence as regards the parent lines, and, in the case of disputes, having a strong moral claim on the Government for redress or compensation in some form or other. But scarcely had these new terms begun to attract attention, when the Government almost suddenly awoke to its duties and embarked on a perfectly heroic scheme of railway extension, in which it proposed to become largely responsible for an expenditure of £6,000,000 yearly for three years; and, to add to the confusion of the possible investor, the Burma Railway Company was launched with a sterling guarantee. Later on, in last year, the financial pressure arising from famine and the frontier troubles has considerably upset the above-mentioned vast programme; works have for a time had to be suddenly stopped; engineers have, I understand, been discharged or relegated to some other employment; and railway material possibly left exposed and useless until finances improve.

The history of Indian railways and their relations with the Government is, of course, very inadequately shown in this brief sketch, but some such outline is necessary as a text for what follows. It covers a period of half a century of hard work and some hard thinking, with the result that we have constructed and opened for traffic about 21,000 miles of railway. This now roughly represents about one mile of line for every 15,000 people, and a yearly average of (say) 420 miles. These are very moderate figures, and if I were to compare them with what has been done within, or in less than, the same period in far less promising fields, we should not, I fear, have much to

boast of. I may, however, just mention that by the end of the century, Japan will, in 25 years, have carried out a railway system representing one mile for every 7,000 people; that is, they have done four times better than we have in India. What is most striking in the story are the important changes which have characterised railway policy in India, and the frequent vacillations in recent years. These latter may be attributed to the serious difficulties resulting from the silver standard, which, rightly or wrongly, made it expedient to have recourse to any modifications, in order to avoid serious curtailment of railway extension, while, at the same time, avoiding the undue relief of the present taxpayer at the expense of his successors. I have said elsewhere, that when all the circumstances have been fully weighed, the charges of weakness or incapacity which have so often been charged against the Government have been sometimes unreasonable, and often unjust, and that, indeed, we should more properly credit it with unusual courage and persistence in having done so much in the face of embarrassments which might well have daunted others. At the same time, it is open to question, especially in the face of present developments, whether the policy which has been in force of recent years, and which they have been ostensibly engaged in putting in action, has been one which was best adapted to meet the needs of the country. The Government has, for a long time past, had ample assurance that Indian railways now offer an exceptionally certain field for profitable investment. We know indeed that on the average they now return over 5 per cent. on their capital, and this in itself is good evidence that they are wanted by the people. Their indirect advantages to the State are incontestable. What then are the principal causes which have impeded our more rapid progress? We may concede the unavoidable impediments of Parliamentary interference; the changes of front and delays due to alterations in politics and *personnel* in the Home and Indian Governments; to the many real and some fanciful financial troubles, and the baneful influences of war, famine, and pestilence; but imposing as these causes undoubtedly are, it is nevertheless open to us to doubt whether, by the adoption of some other policy or system, it would not have been possible to have fulfilled the evident needs of the empire more fully and more rapidly; whether in fact a policy could not have been evolved which would have been largely independent of such influences. Let

us in the first place glance at the position we have drifted into at present. We have:—

1. State lines constructed and worked by the State.
2. State lines constructed by companies and worked by the State.
3. State lines worked by companies.
4. Lines constructed with State assistance and worked by companies.
5. Lines constructed and worked by guaranteed companies.
6. Lines owned by native States and worked by the Government.
7. Lines owned and constructed by branch companies and worked by the State.

Added to which are purely native State railways, which do not affect the subject. Now this will appear, I think, to be a very extraordinary condition of affairs, but what it principally indicates is the share—and it is a large share—which the State still has in the direct working and detailed administration of railways. This, I am now disposed to think, is the canker at the bottom of the whole policy of the Government of recent years. It has been, I fear, the predisposing cause of this distorted growth, and will, if not eradicated, persist in its evil influence.

The fact is that the policy of Lord Lawrence, of 1869 to 1870, which resulted in the creation of a State Department for the construction and working of railways, though nominally dead, is still very much alive. It still colours every decision of the Government, and constitutes, often undesignedly, a stumbling-block to the proper progress of railway extension in India. The department, moreover, still exists, and on a large scale. My belief is that the only means of introducing a new and vigorous life into Indian railways is by inducing a free and unrestricted flow of private capital to India, and that this implies the gradual, but eventually complete, abandonment of State administration. The action of interference of the State in railways should be brought down to the "irreducible minimum." It is very difficult to see how the Government of India can now justify the continued existence of a large department for the construction and working of railways, while professing its intention to maintain and indeed enlarge the sphere of action of private enterprise. As regards mere emoluments, it is not an expensive department; but I ask if it is still necessary? It must surely seem that the reasons which led to its formation no longer exist, and it must now be admitted that railways can be made by companies as quickly, if not

more quickly, than by State agency, and can be worked with greater profit. I contend that the continuance of such a department is a standing impediment to any real and whole-hearted encouragement of private enterprise, and presents, moreover, a distinct source of embarrassment to the Government in dealing with the proposals of companies. The policy formulated in 1883-84 was to the effect that private enterprise was to have a free hand as regards productive railways. This, I think, has long been a dead letter; indeed, the very general feeling here is, that the Government has of late been induced to take up the productive lines, and to leave the doubtful ones to private enterprise. Yet we have been repeatedly told by Viceroy and Secretaries of State, in effect, that the main hope of obtaining adequate extension of railways in India was by the help of outside capital. I know that the favourite official view of this, of "private enterprise," is that there is no enterprise in it; that it wants the State to take the risk, and itself all the profit. This may appear to be the case in some instances, but when, as happened last year, a firm offer was made to Government to supply capital for constructing some 350 miles of railway in the Punjab without any guarantee whatever, the reply was that certain of the lines were not wanted, and others would be made by the Government! Those which were said to be not wanted were, in fact, lines which would have developed new areas urgently needing railways, but which would have, perhaps, temporarily reduced the earnings of a State railway. The lines made by, or allowed by, the Government are termed feeders, while those originated by private enterprise are, I understand, too often characterised and declined as being "bleeders;" that is to say, that though they may open up new ground, they will, or may, reduce the direct profits of the State. These are ideas which arise, I fear, from the existence of a large State Railway Department, influenced, I admit, by the traditional timidity of the Financial Department.

Let us turn for a moment to the point I have just mentioned, as to the want of real enterprise in the offer of capital from this country. The grounds for this are that money is not, as a rule, forthcoming without a guarantee in some form or other. English investors, and particularly financiers, are uncommonly shrewd and wary gentlemen. The figure that is asked, or, at any rate, that is at all likely to be granted, is a minimum, sometimes a danger-

ously low one. What in effect the financier, as representing the investor, says is somewhat as follows:—"The project before us seems sound, as far as our information goes, and may turn out to be a very good thing; but India is a long way off, and promoters are sanguine people. Can we not get the Government, if they sanction the scheme, to either endorse our opinion in words, or to guarantee the minimum figure on which the investor will venture to put down his money?" This may be called want of enterprise, but most people would call it business. If the Government of India really desire to get in outside capital, at any rate at present, they must have the courage of their opinions. In fact it has been so from the beginning, and is so still. A large proportion of the money which is being spent, or is intended to be spent, on the great programme I have alluded to above, has been, or will be, raised on debentures with a sterling guarantee of the lowest possible figure, while the new branch line terms give a guarantee also, but, as indicating the unstable ways of Government, in rupees. It must be carefully noted that the risk incurred by the Government in giving a guarantee has, and should obviously have, some compensation in the shape of a share of surplus profits (generally the lion's share) over and above the figure guaranteed. If then the demand for a guarantee is the basis of the allegation that there is no enterprise in the supply of capital for Indian railways, the official mind must rid itself of this bugbear, or come under its influence only when it finds that capital can be had without guarantee for similar undertakings in equally remote parts of the world. The few instances to the contrary at the present time only serve to prove the rule.

What I would urge is that the ground covered by the companies is now so large that the Government of India can throw off the incubus of a large Railway Department, and reduce it to the extent of providing only for the control and inspection of railways; that the direct action of the State in making and working railways should cease; while adhering steadily to the policy it has had from the beginning, of ensuring that all railways in India shall become public property, and that in future railways should be constructed by and leased out for working to companies. We should then have a clear, readily-worked, and, so to speak, autonomous system. There is, I know, an idea that the Government of India must maintain a staff for making or working

frontier railways as a field for the training of military engineers, or as a source for rapidly collecting rolling stock for frontier operations. This is an argument which sounds well, but has no real validity. To meet the first point, no railway administration would refuse, or be so unwise as to refuse, to employ a certain number of Royal Engineer officers on its staff, and if thought necessary, this could be made a stipulation in all new contracts. As regards the second point, the Government has only to pass a brief Act, such as was passed by the French Government in 1870, to enable them to have complete control of any railway in time of war, under the orders of military railway directors and station commandants. Even without these powers, the Government had full and most satisfactory experience of the action of railway companies' officers during the second Afghan War, on the line between Kurachi and Lahore.

In putting forward my opinion that the Government should confine itself to the function of control, while obtaining the railways as public property, and working them through the agency of companies, it is necessary to record a warning against the present policy of adding year by year to the mileage of the existing companies in the fear apparently of creating any new ones. At present, the railways in India are principally under the control of 14 large administrations, which, with their present open mileages and lines under construction, will before long stand approximately as follows:—

Railways Worked by Government.

	Miles.
North-Western State	3,800
Eastern Bengal State	950
Oude and Rohilkund	1,000
East Coast State	850

Railways Worked by Companies.

East Indian State	2,250
Bombay and Baroda	2,300
Bengal Nagpore	1,250
Indian Midland	1,100
Great Indian Peninsula	1,650
Madras	900
Southern Mahratta	1,560
South Indian	1,100
Bengal and North-Western	1,250
Burma	1,154

Now, compared with the largest of the English or American systems, three only, and particularly the North-Western State Railway, reach or exceed their figures, but it by no

means follows that because there are such large mileages in England or in North America under one administration, that this centralisation is good, or, in the widest sense, economical; still less, that such large mileages are suitable for India. The great English and American systems have grown up under a variety of causes, which have compelled the formation of these vast concerns, and which causes are still in operation. I feel sure that most of the men who have had the experience of dealing with systems of such dimensions, will allow that they are too large for really effective control and supervision of the thousand opportunities for waste, laxity, and loss of business which are constantly coming forward in the management of a large railway; knowing, as they do, that it is in the savings of pennies that the pounds of a dividend are produced, especially under the stress of keen competition. But whether very large systems are good or bad elsewhere, I am satisfied that they are a mistake in India; while there, moreover, the Government has the power to prevent it, in being the actual or potential owner of all the railways. The conditions under which railway management is carried on in India differ very widely from those found in Europe. In the forefront stands the enervating influence of the climate, during at least six months in the year. Next to this are the frequent and inevitable changes in the staff, due to sickness, death, or family cares. These imply that both the head of a line and his heads of departments must be frequently in personal touch with men new to their districts or duties; and the native staff, which, of course, largely outnumbers the European officers, requires incessant watching. In short, successful management in India implies constant movement about a line, and the attention to details which elsewhere, if they arise, can be safely left to subordinates for disposal. This means that only men of first-class physical and mental capacity can stand the strain, and even then, not for long. Ceaseless change of men, and consequently of ideas, is the normal condition of all work in India. The selection of a good man for a manager, agent, or head of a department, in the majority of instances, means that he can only be depended upon for a continuous service of a few years, and that a substitute has then to be found who will come in for a shorter or longer time. The conditions imply that the heads of a railway, or the heads of departments, are men difficult to find, and that, when found,

should not be overworked, or in other words they should not be required to undertake duties which, possible in Europe or in North America, can only lead to rapid breakdown in India. For these reasons, and with a very sufficient experience of what railway management means in India, I am of opinion that a system of 1,500 miles should be the limit to be entrusted to one administration, and that it will be a fortunate thing for a company to find a succession of men who can face the mental and physical strain that this involves. Unfortunately the mistake of creating huge railway administrations very rarely shows on the surface. There may be loss of traffic, wholesale waste, or speculation, with resulting loss of revenue, while the line still shows what is accepted as a proper and reasonable dividend. When existing contracts expire the Government will have a free hand in the redistribution of the limits of each administration. Within the next two years two important contracts expire, while in less than ten years hence the contracts of the last of all the old guaranteed lines will have lapsed. The only State railways now still worked by the State are the Eastern Bengal, the Oude and Rohilkund, the East Coast, and the huge and unwieldy North-Western system. These will doubtless be made over ere long, in whole or in part, to working companies, and their territorial limits decreased or enlarged as may seem advisable.

I have laid stress on what I should call the pernicious element in the present policy of the Government, *i.e.*, the retention of the idea that the State must continue to exercise direct action in both the construction and working of railways. I have implied that this cannot co-exist with really vigorous life in private enterprise, and that it is the latter to which we should look as the ultimate and sole agency for such operations. If we can persuade the Government to take this up as the permanent basis for their policy, and then deal with proposals promptly, reasonably and consistently, Indian railways would only need stability in exchange to become a popular field for investment. That this is not now the case goes without saying. I do not here refer to investments made by corporations which must be satisfied with 2½ or 2¾ per cent., which have no soul for enterprise, or indeed the power to deal with their funds under any such conditions—I refer to the class of investor whose enlistment is a source of strength both to the Government and to the company he is

concerned in, to those who, protected by the assurance of a definite and permanent policy, will be prepared to take reasonable risks, and consequently to interest themselves in the management of their own venture, and in the progress of the country generally. We cannot, I know, do without the debenture-holder; indeed, he is generally the backbone of finance, but, at the same time, it is most desirable to encourage the growth of what I may term "flesh and blood" in those who provide capital for Indian railways. We want to increase the number of people who will have a real and sustained interest in the prosperity of India. This view has doubtless had some influence in inducing the Government recently to favour proposals for the formation of small companies in India, with the idea that capital would be forthcoming from native investors. The idea is a plausible one, but I shall, I think, be right in holding that the source which is here attempted to be tapped, is a feeble one, and that, in reality, most of the small amount of capital which has so far been ostensibly raised in India in this way has been really found in London. I do not, of course, refer to larger amounts that have been invested in this direction by native States. This it is desirable to encourage in every possible way; but to expect that any considerable amount of private capital can be found for railway extension in India, either with a 3 per cent. rupee guarantee or on other similar terms, is to expect the impossible, at any rate at the present time, when bank rates vary between 8 and 12 per cent.

In urging that the proposals of promoters should be dealt with promptly, reasonably, and consistently, I do not wish it to be supposed that the Government of India should be charged with acting otherwise intentionally, but the fact remains that the first of these essential conditions has, until quite lately, been ignored, while the others may have been due to "day-to-day" changes of policy. As to promptness, we have now some relief in the recent institution of an annual committee in India for considering and deciding upon railway proposals. To this extent promoters of Indian projects are placed on a similar footing to those at home. But the Indian committee is wanting in two essential features of a Parliamentary inquiry, inasmuch that it is closed to the public, and that it does not encourage, nor, as far as I am aware, allow the presence or advocacy of representatives of promoters. It is, in effect, a secret committee ;

its proceedings are not even made public, and, in some instances, to my own knowledge, the decision of the committee has not even been communicated to the promoters. If I were to launch an allegation of unreasonableness and inconsistency against the decisions and agreements made with projectors, I should, I think, be supported by nearly everyone who has interested himself in Indian railway schemes, and now that I see things as it were from the outside, in the course of business here, I cannot but admit that there might be, or even that there is, good ground for such allegation. It may be granted that the attitude of a Government towards the representative of a company, or that much-maligned individual, the promoter, should be deliberate and cautious; it may be granted that no two projects have precisely similar conditions, and we may make full allowance for the very human desire, well-developed in the Government of India, to catch whales by baiting with sprats; but I cannot believe that it is necessary, or that it is good policy, to allow such considerations to have so much weight as to prevent the possibility of having one simple and standard form as a basis of agreement for all new projects, instead of the complicated terms and conditions which result from undignified higgling on both sides. There is now no certainty whether capital will, or will not, receive a guarantee, or, if this will be given, whether in sterling or in rupees; no certainty as to share of through traffic or of surplus profits; while the restrictions and uncertainty as to the amount to be allowed for financing and floating a company seem to be determined more by chance than by considerations of the conditions of the scheme, and of the money market, at the time. Under such conditions, there need be no surprise at the feeble response which has been made of late years to the offers made by Government to private enterprise in railways. Yet if money is wanted for a colliery, a jute-mill, tea gardens, inland steam navigation, it is, if the scheme be well supported in its first stages, raised without difficulty, and being free from the action of the Government, the negotiations are conducted and brought to an issue promptly, reasonably, and in a businesslike way. But to promote a railway scheme has hitherto meant months, or, more generally, years of negotiation, of reference to and from the Government at Calcutta and the Home Government, and of certainty that if an affirmative decision is obtained, it will be surrounded with conditions or restrictions such as

to make it most difficult, if not impossible, to finance.

I must now turn to what I may call a minor, though still exceedingly important, phase of recent railway policy. I refer to the old-standing question of gauge. I have mentioned that the gauge fixed at the first for the trunk lines was $5\frac{1}{2}$ feet, and that this held the field until 1869-70, when the metre-gauge was introduced for subsidiary or feeder railways. I think that no other particular virtue was claimed for this distance between the rails over 3 feet or $3\frac{1}{2}$ feet, than that it might be the thin end of the wedge for forcing a metric system on the country, and the unfortunate State railway engineers were charged with initiating it, a task which added much to their day's work, and enriched their vocabulary in a certain direction. I need not detail their troubles; it is enough to say that the gauge alone remains as the fragmentary result of a well-intentioned effort. The original scope of metre-gauge railways, *i.e.*, as mere branches from the main lines, was very soon largely widened. It has become the gauge for large arterial systems, embracing many hundreds of miles, and carrying a traffic as heavy as that offered on many sections of the broad gauge. More than this, these metre-gauge systems have been extended so as to become competitors in the same field with the broad-gauge lines, and have consequently increased the difficulty of the problem of determining territorial limits. A prominent recent example of what this may lead to, for want of fixity of principle, and as an evidence of the way in which the Government itself is open to attack in working State railways, is to be seen in the Government having been forced by pressure from home, to make a metre-gauge line alongside its own standard-gauge line, between Lucknow and Cawnpore, in the interest of a metre-gauge company. Had the State railway been under administration by another working company, there can be but little doubt that this very questionable operation would have been stayed. Ever since the introduction of the metre gauge, the gauge question has produced an annual crop of difficulties of more or less importance. In 1889 a serious attempt was made to arrive at a systematic demarcation of the geographical limits for each gauge, and a proposal was sent home to the Secretary of State (then Lord Cross), in which it was suggested that certain areas, then occupied by the metre-gauge, should be reserved, as a rule, for that gauge; but that, exclusive of these

areas, it should be an absolute rule that no new main line should be constructed except on the standard-gauge. It was also proposed that no material expansion of the existing metre-gauge systems should be allowed, and that even the area now in its possession should not be held to be permanently surrendered to it, in view of the possible future necessity of adopting a uniform gauge. These proposals received no practical support from the Home Government. The whole question is now in greater confusion than ever, and is now further complicated by the introduction of gauges of $2\frac{1}{2}$ feet and 2 feet for branches from the main lines. These in their turn may develop into important systems, and we seem to be drifting, in this matter, in a condition of chaos. It is, in my opinion, most urgently necessary that this question should be the subject of inquiry and decision by an authoritative committee, and preferably in this country.

In concluding this paper, I must freely allow that it very inadequately fulfils its title; but I may urge that within such reasonable limits as I can expect your patience to extend to me, it is impossible to do more than make it a suggestive contribution to your record. I should also add, that I particularly desire to deprecate the idea, that in what I have said, I may have given too little credit to the Government of India, for its earnest and sustained efforts in recent years, to continue the progress of railway extension in the face of most serious obstacles. I have had no such intention. To the administrations of Lord Lansdowne and of Lord Elgin, in this, as in many other directions, our Indian Empire owes a deep debt of gratitude and ungrudging acknowledgment for the courage and devotion which, in the face of perils on all sides, has, while maintaining the credit of the country, done so much for its public works. What I have mainly aimed at, is to suggest that recent railway policy has been influenced by a disturbing factor which, if eliminated, might have lessened our troubles and enabled us to show better results.

DISCUSSION.

The CHAIRMAN said he had to move a cordial vote of thanks to Mr. Horace Bell, and they would all agree that this was an admirable paper, giving a very comprehensive view of the general railway policy in India; that the opinions expressed in it were bold, and at the same time the author went into practical details of the highest value to all interested in Indian

railways. He had framed, certainly, a formidable indictment against the direct administration of railways by the State, and wished to confine its efforts to control over those lines. In that matter he sympathised with Mr. Bell a good deal, but was surprised that he should think it possible, when the Royal Engineers in India had got hold of railways with all the possibilities of power and patronage that such an administration offered them, that they were at all likely ever to let go their hold. He thought he underrated both their power and tenacity of purpose if he imagined that the views he sketched out could ever be carried into effect. They would have to reconcile themselves to State administration in India. He had no doubt that the company system was originally the best, that Lord Dalhousie was an exceptional man who went to India as Viceroy at a fortunate moment. He had that gift which distinguished a really great man from men of mere talent, the gift of foresight. He took very broad views of what could be accomplished by the construction of railways in India; he did not want to make them pay immediately, for he knew that could not be done—that they would have to create their own trade to a great extent, but he hoped that in the future they would indirectly benefit the country even more than they benefited the shareholders. No doubt his conceptions of a really grand railway policy had been fulfilled in a far higher degree than he could have hoped for, for railways had conferred inestimable benefits on India. If they had gone on, on the same system, although no doubt terms were agreed upon originally which gave the shareholders a large return for their investment, and they might have been modified; if the Indian Government had confined themselves to this one system of raising money he believed they would have done much better than by all the changes to which they had had recourse. He quite agreed that the Indian Government were hampered by the necessity of finding money. They imagined that these railways would not bring in the revenue they had done; they had not the same faith that Lord Dalhousie and Lord Cromer showed afterwards; they thought they must get money somehow or other, and were at their wits' end how to construct railways without burdening the revenues of the country. No doubt they were bound down to a considerable extent by their dread of transgressing the resolution passed by the House of Commons, which said that railways should be extended, but at the same time there must not be any increase of taxation in India. No doubt they made a great mistake in the time of Lord Lawrence in introducing an entirely new system. The metre gauge was a colossal blunder. He did not say there was no use for metre gauge railways in their own proper sphere, but to introduce a break of gauge on grand trunk lines, really cost that country millions of money. The blunder had to be repaired at any cost, and the railways were pulled up, and the broad gauge laid down again. Even now there was the monstrous

system of having a break of gauge on the important trunk line between Bombay and Delhi, which the Chambers of Commerce of Bombay and elsewhere vainly protested against. There had not been much done in the way of extending the original blunder, and, as far as his recollection served him, the only metre gauge which had been sanctioned within the last year or two, was the short line for linking up the great metre gauge system which now extended all over India, and it was undoubtedly necessary to bring those lines together, and have a complete metre gauge system so that the rolling stock could run over continuously. Another point Mr. Bell referred to was the difficulty of saying whether the guarantee should be given in sterling or in rupees, but that appeared to him a comparatively small point, because the man who put money into an investment of that kind, if he were going to get his interest, paid in rupees, would make the terms such that the payment would cover the exchange. He had to convert his money ultimately into sterling, and if it were paid in rupees he would naturally ask for a little more in the way of interest to cover the cost of exchange. Mr. Bell defended the guarantee system, saying that private enterprise would not invest money in Indian railways without a guarantee of some kind. He did not suppose that would ever have been possible. Certainly, it was not possible after all the best routes in the country had been connected by highly-subsidised lines to get investors in this country to put a large amount of money into schemes which were not likely to be so profitable as the original ones and get no guarantee. He did not know of any country where English investors put their money into large public works without some concession from the State. Mr. Aird was now carrying on a tremendous work on the upper part of the Nile for irrigating an immense extent of territory never cultivated before, and he was to receive a very valuable concession from the Egyptian Government, and the payments were to be extended over thirty years. It seemed to him to be a very valuable work he had undertaken, and it was quite certain they would not be able to abandon Egypt until Mr. Aird was paid his money. That was an example of the kind of great public work that English capitalists undertook abroad; there was nothing at all exceptional in the Indian railway system, which on the whole had been justified by the great results already obtained. Taking the guaranteed railways alone, apart from the works constructed by the State avowedly for military purposes, the results were simply magnificent. You could only judge of them by counting the old East Indian Company as one of the original guaranteed companies. It was now put down erroneously in the railway returns as a State line, and so the great revenues of that wonderfully productive line were credited to the State instead of to the guaranteed companies. There was unquestionably room for the construction of a great number of new railways in India. Perhaps it was going a little beyond the scope of the paper to suggest that it would not be

a bad thing if the Indian Government were to take a more imperial view of the mode of furthering their productiveness. It always seemed a pity to him that the Government out there had lost the initiative in making great imperial changes in the way of public works. They were bound down by the old notion that they were only to make railways within India itself, but would it not be very advantageous if they could help in accomplishing some such scheme as was suggested 30 years ago of making an overland route to India? Russia took the initiative in making an overland railway across the length and breadth of Asia, whilst we did nothing in that respect. He was convinced that it would be an advantage to the Indian railway system if—as was suggested lately in a paper read at the Imperial Institute—we continued the line down into Ceylon as far as Colombo, one of the great naval bases of the East, and if in the north they were not afraid to push on the railway system to Candahar and to Herat, and to have a really overland line to India constructed throughout Asia. That would be worthy of the imperial reputation of England, and would be a great work, which, if not immediately productive, would be to the advantage of our power and prestige in the East. He must apologise for referring to this matter, but it was one which he had often mentioned in the House of Commons, and was always told that it was far in advance of the time. He was sorry to see Russia was undertaking designs which England shrank from, and thought it would be very much better for our character as a great ruling power in the Asiatic continent if we showed greater rivalry with Russia in that matter.

Mr. W. S. SETON-KARR said he should not discuss the various modes of constructing railways in India, or touch on the battle of the gauges, but should confine his remarks to the commencement of the railway system, which he well remembered in the time of Lord Dalhousie, and which was foreshadowed by Lord Hardinge. His friend Sir George Campbell used to say that in India official life was very short, but official productions were very long, and Lord Dalhousie's celebrated minute on railways was no exception to the rule, for it contained 101 paragraphs, and really led on to the construction of all the extensive lines to which Mr. Bell had alluded. There was considerable discussion at the time, and he had it on the highest authorities, including Sir John Grant, that had it not been for the guarantee by Sir Charles Wood, afterwards Lord Halifax, of 5 per cent. paid to capital before the line was opened, the construction of Indian railways would have been indefinitely delayed, or certainly it would not have attained the proportions it had. He remembered perfectly well that by the direction of Lord Dalhousie, he wrote the letter to the late Charles H. Lushington appointing him Special Commissioner to make over the land to the railway company which involved compensation to the tenants who were disturbed, and a reduction of revenue to the Zemindars through whose

lands it passed. As an instance of Lord Dalhousie's sagacity, when there was a little discussion whether land should be taken sufficient for a double line or a single, he said with his characteristic promptness, "Take it for two lines; they may not be wanted for some time, but they will be wanted some day." He also recollected that in the Mutiny the railway was only opened to Ranigunge, 120 miles from Calcutta, and General Neill and the Madras Fusiliers who came up to take part in the operations, were sent forward from that terminus in carriages of six or eight men in each. In 1860 the railway was opened from Calcutta to Rajmahal, which is now on a branch, but was then a terminus. A luncheon was given to celebrate the opening, and the late Sir John Grant amused the guests by saying that while these trips had occupied six or eight hours, in 1828 or 1829 he had gone up the country by the Sunderbunds and arrived at Rajmahal within a month, and was congratulated by his friends on his prosperous and rapid journey. There was one slight mistake of date in the paper. Lord Lawrence was not in India in 1869-70, but left at the commencement of 1869, and the railway administration, though no doubt improved and modified afterwards, was then in the hands of Lord Mayo. When the speaker left India at the close of 1896 there were some 5,000 miles of railway open, but he learned now that there were more than 20,000. How this had contributed to the security of the State, the promotion of commerce, and the relief of famine, they were all as well able to judge as he was.

Sir JULAND DANVERS, K.C.S.I., said he had been connected with Indian railways from their infancy, and it was naturally interesting to him to hear an account of their rise and progress from so qualified an observer. He recollected very well the discussions in this country when proposals were first brought forward of this kind. There was Lord Dalhousie's grand proposal for trunk lines, and the suggested policy was to commit them to companies. The discussion took various forms, and there were great differences of opinion. Some thought it was premature to attempt to introduce railways at all, and he recollected one gentleman of long Indian experience who expressed the opinion that the railways might be made but the natives would never use them. The opening of the first railway showed how erroneous that idea was. The terms of the original contracts of course were such as would not be dreamed of in the present day, but circumstances then were very different. At that time the value of money was very different; India was unknown and many circumstances existed which prevented private enterprise from embarking in railways in that country. It was absolutely necessary for the authorities, consisting of the old Court of Directors and the Board of Control, to conceive some plan by which capitalists might be induced to furnish the money. The discussion ended in much higher terms being granted than might have been expected when the thing was first mooted. At

first he believed 4 per cent. would have been sufficient, but the money market changed and before the agreement was entered into 5 per cent. was found to be necessary. Railways had gone on and the scheme of Lord Dalhousie was commenced and carried on without interruption, through war, through mutiny, through disturbances of all kinds, through famines and financial difficulties. Then after a time it occurred to the Government that a change was desirable. The railways had been costly, the results were not such as had been expected, and they thought something should be done to ensure economy. The new plan was introduced by Lord Lawrence and carried out partly by Lord Mayo. He was rather amused at that part of the paper which referred to the jubilant state of the service of which the reader of the paper was a member when the decision was arrived at, and equally pleased to find that after mature reflection he came to the conclusion that the agency of companies was upon the whole the most satisfactory mode of carrying out railway enterprise. That seemed to be now the opinion of the Government. Railways being commercial concerns were better in the hands of those who could manage them on commercial principles. At the same time the Government should retain in its hands the right of ultimate proprietorship, and should also have a controlling power to see that the interests of the public were duly considered. When that was done it seemed to him that if the choice was between a State and a company, the latter was on the whole most desirable. He believed that half the present large extent of railways would not have been finished but for the influence of companies. Mr. Bell had referred to the variety of methods which had been attempted. These vacillations of policy were not without their use, for in the end he believed the fittest would survive and the authorities of the day would be able to choose which was the best system for future adoption. It appeared to him that the Government had now come to the conclusion that by whomsoever the railways were made they should be worked on commercial principles by a joint stock company. The great thing was to take care that a free hand was given to the managers, not interfering unnecessarily or in a way which became irksome and discouraging. The main policy should be to promote the extension of necessary lines and to ensure their efficient management.

Lieut.-General Sir RICHARD STRACHEY, R.E., G.C.S.I., said no one in the room could doubt the enormous importance of railways to India, neither could anybody who knew what railway construction and management was question the great difficulties that necessarily arose in creating and developing a system of railways in such a country as India. It naturally fell to the Government to initiate the scheme under which the railways were developed, and though it would be absurd to say that everything the Government had done had been wise, yet, speaking generally he was satisfied that what had been done had, humanly

speaking, produced as good results as could have been anticipated. The difficulties in the way were very great, and the greatest of them were those attending their financial consequences. It was all very well to talk about the advantage of making railways, and making them rapidly; of course, this was desirable if it could be done, but to attempt to construct railways at anything beyond a moderate speed led to trouble and difficulty, and if it had been pushed too far would have led to serious financial trouble. How could you possibly have covered India with thousands of miles of railway, and bring home profits to pay the necessary charge on the capital invested, unless the commerce of India had developed sufficiently to admit of the remittance? It was impossible. Equally, until the country became fitted for the increased and improved system of communications, railways would have been thrown away. The propriety of a good deal of what the Government had done might be questioned, and no doubt their policy had been wavering; for a long series of years they might be said to have had no policy, but that again was not a little dependent on the fact which had been alluded to, that the life of an Indian statesman was very brief; moreover, the peculiar constitution of the Government of India had practically placed the control of the railways in the hands of gentlemen who knew absolutely nothing about them. He was speaking of those at the head. The officials under them, the professional authorities of whom Mr. Bell was a specimen, had been excellent but the gentleman in the Council of the Governor-General who, from time to time, had charge of the railway administration could have had no experience of railways, and his brief tenure of office did not admit of his acquiring the knowledge or experience which alone would make him a satisfactory head of that branch of administration. What might be the remedy was another question, which he would not attempt to answer, but the difficulty was no doubt great. The advantage which was obtained in England from the prolonged experience of members of the House of Commons in controlling railway administration and construction it was impossible to obtain in India. There was no means of establishing a body of control such as a committee of the House of Commons. Mr. Bell had referred to a committee which the Government of India had started to discuss railway questions, but, as he said, it was a secret tribunal, nobody outside of it knew what was to be put before it, the nature of the conclusions arrived at, and still less the grounds on which they were come to. If there were competing interests to be considered, none of the parties concerned received the smallest intimation of what was going to be brought before the committee. No doubt the intention was excellent, and perhaps it enabled the Government officers to bring their ideas together and form the best conclusions they could. The Chairman had referred to the tyranny and predominance of the Royal Engineers, in the Indian Public Works Department, and

he might be glad to hear that that was gone so far as railways were concerned, for railway administration was no longer mainly in the hands of the Royal Engineers but of Civil Engineers. No doubt a certain number of subordinate officers were Royal Engineers, but the virtual head of the Department was a civilian, and so were the chief officers. Naturally he did not consider a man any the worse for being a Royal Engineer, his experience was altogether in the other direction, and he was happy to say that the officer now in charge of the railway with which he was chiefly concerned was an R.E., and his management of the East Indian Railway, the magnitude of the traffic on which approached some of the larger English lines, was unsurpassed. He was surprised that Mr. Bell had not made more specific allusion to the great change which took place in the management of the East Indian Railway in 1880, when it was bought by the Government, and its administration under the company which was then re-constituted began. As he understood, the disposition of the Government since that time had been to entrust the working of the railways to companies, leaving the ownership in the hands of the Government, and he thought that this had grown into an established policy. He agreed that Government ought to exercise control, but at the same time it should be exercised in a reasonable way. Interfering with small details not only did no good but did mischief. If the whole of the petty expenditure was to be overhauled by the Government officers the result must be that the companies' officers naturally took less care than they otherwise would; it destroyed their sense of responsibility, which was a great evil. With regard to what Mr. Bell considered the tendency to excessive growth in the magnitude of Indian railway administration, he ventured to doubt whether this had really gone too far. The East Indian Railway (to which he had given rather more mileage than it really possessed) was almost the largest, but was certainly one of the best, if not the best managed of any railway in India; he did not think any one denied that. There was a great advantage in many respects in having a considerable mileage. The incidence of the general charges were reduced, the scope for making improvements was increased, and also the power of the railway to be liberal to the public.

Lieut.-Colonel E. L. MARRYAT, R.E. (Bengal and North-Western Railway Company) said it was not necessary to go much further into the past, for in spite of all the alterations of policy there were now over 20,000 miles of railway in India, earning on an average $5\frac{1}{2}$ per cent. on the whole capital, and he did not think any other country in the world could say the same. That spoke well for the Indian Government, but what Mr. Bell was looking to he thought was rather more to the future, and what he wanted was first to do away with the Government State Railway Department, appearing to think that if that was done away with, private enterprise would have a freer

hand. He thought that would be impossible, because every important line was now, or would shortly be, the property of the Government, and therefore the Indian railway system was a huge monopoly. Take any huge monopoly like the Post Office, and you found they were not anxious to encourage private enterprise; they did their best to put down boy messengers, and everything else of that kind. Private enterprise, therefore, could not have a free hand. India did not now want a big heroic system of lines, but a large number of small lines, from 20 to 30 miles in length, to feed the trunk lines, and it was very difficult to get capital for them. In the first place the large companies were not always anxious to have smaller companies to make them. As far as the system with which he was connected was concerned, it intended to keep all the good branches for itself, but if there were any branch which seemed doubtful, he should be glad if somebody else would make it, and no doubt most other railways looked at the matter in the same way. Again, the terms which the Government offered of 2 3 per cent. rupee guarantee were absurd when money in the Bazaar fetched 15 per cent. and Government 3 and $3\frac{1}{2}$ per cent. rupee paper was considerably below par. They might talk about the investor making lines, but as a matter of fact the investor did not make them. When a railway came out it was taken up by financial houses, and a very small proportion indeed was taken up in the first place by the investor. These financial houses had to live, and they wanted something better than the Government or the Secretary of State would let them have. The consequence was that you could not get any money until greater inducements were offered. The gauge question was now settled. Mr. Bell talked about the effort made in 1889 to prevent any extension of the metre gauge, but that move failed at once. The fact was that it was simply an attempt to crush out the metre gauge, got up by a broad gauge and military clique. In one point he thought the author was a little inconsistent. He first blamed the Government for not helping private enterprise, and then when he came to the instance of linking up the metre gauge system across to Lucknow, he condemned them, and said it was a questionable operation which would never have been done if it had not been a private company. It was, however, the opinion of a distinguished railway man, that if a similar case had occurred here, instead of taking six years to get it done, a Parliamentary Committee would have done it in six months. If they wanted a further increase of Indian railways, a 4 per cent. rupee guarantee would perhaps do it, but at any rate he hoped when they got a gold standard or a fixity of exchange, English capital would flow to India for this purpose.

Mr. J. A. BAINES, C.S.I., said he came entirely as a learner, to sit at the feet of his friend, Mr. Bell, whom he regarded as a broad-gauge Gamaliel, and though he was never connected with railways, he had pleasant reminiscences of the sundry conflicts

in which he engaged with the Railway Department when he was in India. There were only two points on which he ventured to say a word. One was the extension of railways, and the other, Government agency. It was very misleading to talk, as was done in one part of the paper, of the ratio of mileage to population. It all depended on how the population was distributed. You could not take any single standard of that sort for all countries. You could not adopt the same criterion for Bengal as you could on the prairies of Western America. To judge of the efficiency of a railway, you must look to a combination of circumstances. If you wanted statistics of that sort, you must take the mean between population and square mileage, and compare it with the lineal mileage, but even that would not be a very good criterion, though it would serve to compare one province or country with another. The question was whether a railway paid or not. It paid best when it exactly suited the circumstances of the country. If you over-railwayed a country, you lost money, and if you under-railwayed it, you lost the development of industry which the traffic gave you. Owing to unrestricted competition in America and some of our colonies, it had happened that you had an immense mileage of railways which did not pay at all. Japan had been rapidly developing her railways, but he doubted whether they would satisfy that criterion. In the same way, long railways in Canada were constructed not merely for revenue purposes, but almost as financial undertakings, and were based on land administration as well. It made all the difference whether you ran railways through a new country which required to be developed, or through a country like India, which was already filled up. With regard to Government agency, it was a question which it was possible to argue at great length, and he did not quite understand whether Mr. Bell agreed with Sir Richard Strachey about the control of the Department, but he gathered that the general gist of the paper was that Government control should still be maintained, whatever happened to the management. On the other hand, Sir Richard Strachey told them that the administration of railways was very good, so far as the subordinate officers were concerned, but it was the individual control which was inefficient. He was much of the opinion of Mr. Bell. He should like to see railways placed under the general control of the Government, but without its taking part in the direct administration. When a large undertaking of that sort was placed in the hands of a State Department, there was always the danger of its being throttled by too rigid adherence to custom, but the great objection was the political one, that it was perfectly impossible to safely leave these large undertakings in State hands, under a system of representative government, where the party system prevailed. If you had these enormous interests, and these enormous armies of employees under State agency, you were certain to get either political or

pecuniary corruption. That was seen in Australia, and a serious question had been raised in Canada whether the Canadian Pacific Railway was not already becoming too great a political factor in the State, not only from its possession of land, but from the number of its employees. Every year there was a great increase of mileage, new workshops established, and thousands of men employed, and, at one time it was said that the Canadian Pacific could control the party distribution of the Canadian Parliament. That seemed a very serious objection in two of our greatest colonies, and though in India it would not be so bad, because of the very small proportion of employees of our own race, even there, there would be great danger of political difficulties from having Europeans sparsely scattered about in the midst of the native population. They might be very loyal, but they knew perfectly well that half-educated men sent out there were very likely to establish relations with the natives which no Government could possibly approve. He spoke rather strongly on this point, because they had had an instance at home in the Works Department of the London County Council, and he might say that he was himself an avowed opponent of any material extension of the direct employment of labour by State or municipality.

Mr. E. A. CAZALET (President of the Anglo-Russian Literary Society) said, the question had been raised in the paper, and referred to in the discussion, of the management of railways by Government or by private companies. He was always convinced, as most people were, that private companies managed railways and most other things much better than Governments, but he had lived a good deal in Russia in former years, and went there a month or two ago on a visit, and he came back with the conviction that since the Russian Government had taken over many of the railways from the private companies the results in the interests of the country had been satisfactory. They had the power and the means of diminishing the tariff both for goods and passengers, and the result was that a good deal more money remained in the country. The Russians, who were known to be great travellers, now remained in the country and spent their money in going to the Caucasus, the Crimea, and other places instead of to the mineral springs of Paris, Carlsbad, the Riviera, and so on. Another country very different from Russia in every respect, namely, Switzerland, had just adopted the system of buying up the private railways, and they were going to be conducted by Government. The Swiss were a shrewd people who knew pretty well what they were about, and he thought these two facts with regard to Russia and Switzerland were worthy of consideration.

Sir OWEN TUDOR BURNE, G.C.I.E., K.C.S.I., said with regard to Lord Mayo's policy in introducing the metre gauge, it must be remembered that at that time the standard gauge was so broad, much broader than the English, that the railways cost

£15,000 to £18,000 a mile, in fact they were much too big to carry the traffic in certain parts of India. Lord Mayo only intended the metre gauge to be used for feeder lines, so that the lines might carry a full freight, and he always looked forward to the time when the interchange between the narrow and broad gauge would be of the simplest kind, as was now carried out in the case of the Barsi Light Railway, where the change of goods and carriages was made with the greatest ease from one gauge to another. The introduction of the metre gauge was not originally intended to be used for great trunk lines as successive Governments had since made them. As a humble outsider he should be very sorry to see the absence of State control; he also regretted the so-called introduction of British capital, and did not think it had been altogether a success. It was, no doubt, necessary, as the Government had not the money to expend, but it had introduced difficulties and claims of every kind, which had led, and would lead, to very great confusion. Sir Richard Strachey had hinted that the East Indian was one of the best managed railways in India, and he should like to say, as a late member of the Council of the Secretary of State, that at the India Office there was only one opinion about that, namely, that the East Indian Railway was not only the best managed but the best financed of any railway in India. As Chairman of Council of the Society of Arts, he must express his thanks to Mr. Bell for the extremely useful paper which he had given them, though he did not agree with all that was in it; and also to the Chairman for his kindness in presiding.

The vote of thanks having been carried unanimously,

Mr. BELL said, in reply, that he was sure it would be a satisfaction to the Society, as it was to him, that the paper had elicited a discussion of such interest and importance. He deprecated the idea which had been expressed by some of the speakers that he was in any way an advocate of any particular gauge; on the contrary he had intended merely to draw attention to the want of system in spreading the different gauges over the country. He must acknowledge that Mr. Baines's criticism was generally theoretically correct as to comparing mileage of railways with areas leased; but in the case of India and Japan it might be fairly accepted. As regards the mileage to be placed under any one administration in India, he was quite ready to allow that Sir R. Strachey's views should have great weight, and that the conduct of the East Indian Railway had been admirable; but we must not be influenced too much by this one example, nor must we even suppose that the East Indian Railway could not do better if it was kept to more reasonable dimensions. It was interesting to future promoters to be made aware, by Colonel Marryat's remarks, that only unpromising branches would be offered them by the Bengal and North Western Railway.

Mr. ERNEST BENEDICT, M.Inst.C.E., writes:—Mr. Horace Bell is to be congratulated on his singularly candid and interesting contribution to a subject on which so much has been written and so much more might be said, the policy or policies or want of policy on the part of the Government of India, with regard to public works in general, and to railways in particular. The author is candid in that he freely criticises the administration of the Department in which he took so important and distinguished a part, and his paper is interesting as proving the thoroughness with which men who attain eminence in India identify themselves with whatever work they may have in hand. The discussion gave a further proof of this. Old officials who, when in office, were amongst the most exacting upholders of the traditions of the Department, when they leave it for good and throw their lot in with companies, become the most caustic critics of official ways, and their bitterness appears to be the greater the higher the rank they formerly held; in fact it seems as if those that have known the secret ways of Government the best during their period of service under it, are just those who consider it least heroic in its policy, and that the greater the familiarity with this policy, the greater is the contempt for it. The writer has little to add to what Mr. Bell has so ably stated, and with almost every word of which he thoroughly agrees. Indeed during the four years for which he was responsible for the views enunciated in the columns of the *Indian* (now the *Indian and Eastern*) *Engineer*, he never ceased to hammer on the same anvil and to the same purpose as Mr. Horace Bell. I will, therefore, confine my remarks to one or two points that seem to have escaped observation, and to illustrations of some of Mr. Bell's remarks. It would have been well had Mr. Bell given us his opinion on the recent rearrangement of the higher Public Works officials, and on the use and abuse of so-called "Departmental" work. In comparing the cost of the older broad gauge lines with the more recent metre gauge railways, the difference in price of the permanent way and of the rolling stock is not sufficiently emphasised. With regard, again, to the loss in exchange, due to the depreciation of the rupee, no account seems to be taken of the occasional rise in the value of that uncertain coin, which rise acts the other way. The difficulty in attracting capital into railway projects is not altogether due to the action or inaction of the authorities, but also to the small dividends that may be expected at the best as compared with those in the other industrial enterprises mentioned by Mr. Bell; and, above all, to the *fluctuations* in the value of the rupee. The "friction with the staff of the companies" still exists. On two occasions, and on two different lines, the writer, when chief engineer, had to reduce the speed of traffic on lengths of line laid with 20-year old sleepers before he could obtain sanction to renew them *en bloc*. In another instance sanction was given to the erection of a boat wharf, but not to the dredging which would

enable boats to utilise it. These instances might be multiplied *ad infinitum*, and a very recent case appears to be the difficulty the East Indian Railway experience in getting sanction for sufficient rolling stock to enable them to deal with their ever-increasing coal traffic. Mr. Bell most openly confesses that the engineers of the Public Works Department "had to learn a good deal, and necessarily at the expense of the State and the public." This process is still going on, and reminds the writer of what his master, the late I. K. Brunel, said to him when he wanted to join the staff of the Eastern Bengal Railway before he was out of his pupilage: "You may go if you like, my boy," he said, "but if you take my advice, you will learn your business in England first, and practice it in India afterwards." The constant change of *personnel* adds to the expense of State railway construction. On the last railway with which the writer was connected, the district engineer was changed five times in twelve months; whereas on the three guaranteed railways on which he worked, the majority of the engineers had been for many years in the service. Indeed, so much was this the case, that another evil had arisen, viz.: the want of new blood and new ideas, resulting in a certain amount of fossilisation. The evils of a mixed gauge have arisen solely from the misapplication of Lord Mayo's policy. It is true that the introduction of any new gauge is to be deprecated on account of the danger of "feeder" lines gradually and almost imperceptibly becoming "main" or "through" lines, when all the advantages of the narrow gauge immediately disappear, and it becomes at once an almost intolerable evil. The principle may be right enough, but its application is apt to lead to undesirable complications, such as the twenty-four junctions and crossings of standard and metre gauges in India. The sudden stoppage of the works on State lines due to diversion of funds is an exceedingly costly operation. The writer has had to take up work thus suddenly abandoned, and can safely say that he could not find half the work and plant with which the works had been credited. The final measuring up is generally left to a subordinate with instructions to be liberal to the contractors whose estimates of profits have been so ruthlessly falsified. Now, subordinates are naturally inclined to be liberal to contractors, especially to native petty contractors, with whom they are generally on the best of terms. The result may well be imagined. Work on guaranteed railways is not subject to these costly shocks, and the programme of work is gone through without interruption, with the same men throughout, who, therefore, have some incentive to carry it out quickly and cheaply. Mr. Bell alludes to new through lines being termed "bleeders," that is, that there are few of them left now but what would compete with some one or other of the existing railways. The linking up of the narrow gauge systems by the new Cawnpore-Lucknow metre gauge line is a case in point, and, therefore, accounts for the author's bitter feelings towards it.

A certain very high Government official once said to the writer, "How can you expect us to look with favour on any new line that will compete with those in which we have such a deep interest?" The treatment of the Delhi-Ambala-Kalka Railway is not such as would encourage the promoters of any similar line. The strength of this opposition is in direct ratio with the thoroughness with which the opponents identify themselves with the undertakings in which they are individually interested. To this the writer has already alluded, and to a rank outsider this battle of giants is intensely instructive and entertaining. The sore question of the employment of Royal Engineers to purely civil posts was raised during the discussion. On this point the writer would only make two remarks: (1st). That, after all, the corps of Royal Engineers, although composed of what may be called the salt of the earth, is but a small body, and that it is, therefore, probable that there are as good fish in the sea as ever came out of the pond. The men employed by Sir Robert Hart are not *all* Royal Engineers, and yet he can pick and choose where he likes. (2nd). That if Royal Engineers would frankly become civilians, not a word could be said against their employment; but it does seem absurd that a military man who, by accepting civil employment, must necessarily become more or less rusty in regard to his military duties, that such a man should be paid more, not only than his military *confrère* who sticks to his last, and presumably thereby becomes daily a better soldier, but also than the civilian, who has trained himself at his own, or his father's expense, and who performs exactly the same duties quite as efficiently.

Mr. W. MARTIN WOOD writes:—Mr. Horace Bell, in course of his useful paper on "Recent Indian Railway Policy," more than once apologised for its inadequacy. With the mass of material that we know he must have had to contend with that feeling on his part was natural enough; but those who have had to toil after and through the tangled history must be grateful to him for the success with which he has reduced it, in his continuous narrative, describing at least seven different systems with their much varied, often inconsistent financial "terms" and conditions of construction. Apart from this retrospect, which mostly teaches what to avoid, his practical object is to suggest "the possibility of having one simple and standard form as a basis of argument for all new projects instead of the complicated terms and conditions," which he so skilfully described. Mr. Bell did not venture to set out any simple and uniform plan, though such settlement would afford immense relief to all concerned. No doubt its principles may be deduced from his former book if read in connection with the present paper and the remarks of the experienced men who commented thereon. Considering what a counsel of perfection would be such a clear and decisive programme towards Indian railway exploitation—after the dozens we have had—

Mr. Bell will be quite right to wait until he shall be called in. He has done his part for the present in clearing the ground. It would not be difficult, also in some respects useful, to point out inconsistencies in the arguments embodied in the paper. In the opening passages Mr. Bell accepts Lord Dalhousie's principle that Indian railways must essentially be "national works," and that the State should exercise "a stringent and salutary control" in the public interests, especially, let me add, those of the Indian people and taxpayers. But the gist of his argument all through—saving certain modifying admissions—is that the control has been too stringent, and on the whole not salutary; hence, that State control has been or is "a stumbling block to the proper progress of railway extension in India." This contention he emphasises by asserting that "the canker at the bottom of the whole policy" of recent years consists in the large share that the State still has "in the direct working and detailed administration of railways." Now, this is a fairly stated proposition, and one that will, no doubt attract the support of the outside financial, ironmasters', and engineering interests concerned. On the other hand, this proposition cannot displace the supreme consideration, already cited, of India's true and permanent national claims. And it must be noted that many of Mr. Bell's criticisms, including the most formidable, that directed against the new departure under Lord Lawrence and Lord Mayo, 1865 to 1869, in the creation of the State Railway Department, are covered and modified by that paramount consideration of responsibility to India and its people, which, as Sir Richard Strachey indicated, has been kept in view by the authorities all through and must be maintained. Having thus very briefly and fairly assessed such force as there is in Mr. Bell's general argument, let me, as concisely as is possible, take note of certain practical considerations and abiding factors that lie beyond that argument, and which were little more than touched upon in course of the interesting debate that followed the reading of the paper. (a) It is too readily assumed, mainly by, or on behalf of the special interests alluded to above, that Indian railway extension has not already gone on as rapidly as is compatible with the financial strain that India can sustain, or that her more urgent necessities require in comparison with other classes of public works. To be more precise, the time has come to consider whether the capital, skill, and labour now demanded to be expended on the previous and present *kind* of railway extension, might not far more profitably, in India's interests, be directed in other directions. Still keeping in view the special service that iron-ways can supply, we must admit that, except for a few patches, they have scarcely touched the real *rural* India. This can only be reached by an entirely different class of lines of simpler and lighter construction; so that it is high time to face the difficult problem of applying the scant funds available, the ingenuity of painstaking, rather

than ambitious engineers to the India of the villages, in which dwell three-fourths of all the producers in the great peninsula. This, as yet, untouched field of railway enterprise will have to be developed from within, as far as possible through local traders' influence and funds, though it might be aided by European capital. This intensive side of Indian railway policy demands serious attention on the part of responsible authorities; though it may not attract City financiers, who must have something cut and dried in the sweet simplicity of at least 2½ per cent. guaranteed. (b) Have not most of the main routes been already provided for? In regard to this question, Mr. Bell's general remarks might usefully be compared with the definite statements as to lines already proposed, as set out in the paper by Mr. J. W. Parry (*Journal*, May 10th, 1895). It is easy to see that several of these schemes, if they do not overlap, will compete for through traffic; while in regard to various projects for reaching Karachi through the barren tracts of western Rajputana, they involve the cost of a monster bridge across the Indus at Kotri. Here comes the imperative necessity of State control; for the Indian railway system must be saved from any imitation of the ruinous "trust" warfare in the United States railway system. Mr. Bell himself supplies one notable illustration of how some extensions have already overrun the present needs of India, when he cites the (standard gauge, therefore costly) Assam-Bengal Railway, of which he says that "it was not urgently wanted, and for two-thirds of its length cannot for very many years be of any practical value to the province." Probably a companion illustration to this may be found, in that Punjab project of 350 miles, which, though he favours it, the Indian Government objected on similar grounds to those he adduces against the Assam line. Hence eager promoters of Indian railways must still be subjected to Lord Dalhousie's "salutary control" by the State. (c) Mr. Bell is evidently one of the friends of "the renaissance of the standard gauge;" but he is under a mistake as to the metre gauge being only intended for branches. It was adopted first, and still is, because the big and heavy system, with its inevitable "dead weight" in traffic, was seen to be unsuited to Indian conditions. It was intended to supply entire divisions of the peninsula as it has done; for where would have been the present extension of 20,000 miles, of which we boast, had it not been for the large application of the lighter, more compact, and more economically worked system? Here again, "the stringent and salutary control" of responsible authorities is required to set against ambitious engineers, and promoters regardless of expense. (d) There is a special and larger consideration that must modify British eagerness for Indian railway extension. In the physical conditions of that tropical peninsula, the absence of workable iron and the scarcity of fuel, a Western railway system is, at best, an exotic. It is

a political, military, and foreign-trade luxury that has its necessary limits. The public works that India needs are water-ways rather than iron-ways; above all, water storage and distribution, so that the food of the people may be secured, and its natural indigenous industries improved and extended by its people themselves. This obligation the Indian Government has very imperfectly fulfilled; it can utilise the surplus funds of the West for the purpose, if it would frankly and freely employ Indian engineering talent and industry for that beneficent object.

Mr. W. M. ACWORTH sends the following notes on Mr. Bell's paper:—

1. *English extravagance in early days.*—Was not the money, lavishly spent in hasty experimenting, well spent, in view of the fact that our rapid construction of railways gave us an eight or ten years' start of our rivals, who by waiting to see our results may have lost more in time than they gained in economy? Is there any evidence that in any other country *English* accommodation, either for goods or passengers, is given at less than English rates?

2. *Gauge.*—We are likely to want a new Gauge Commission in England also to deal with schemes under the Light Railways' Act, 1896. It would seem as though three gauges might be possibly admissible, viz.:—(a) Normal gauge. (b) Either 3 ft. 6 in., metre, or 3 ft. (c) Either 2 ft. 6 in., 2 ft., or 1 ft. 10 in., and the Commission might decide which of the three in classes *b* and *c* should be obligatory.

3. *Government Aid to Construction.*—There does not seem to have been tried in India a system which is common on the Continent, more especially in Austria-Hungary, and apparently successful there, under which State aid is given in the form of subscription for the whole or a portion of the ordinary shares. Suppose one third of the capital of a new line raised by debentures, with a 30 per cent. sterling guarantee, the Government liability on this would be in practice almost nominal. The remainder would be issued as rupee stock, half 5 per cent. preferred, which might be taken up in India, half ordinary, taken by Government. The 5 per cent. preferences would be entitled to share in surplus profits after ordinary shares had received, say, 4 per cent. In this way the Government liability would be gradually and automatically lightened as the line developed. Further, the fact that the profits on the new line accrued so largely to the State might tend to lessen the natural hesitation of State officials to permit possible diversion of traffic from existing State-owned or State-aided lines, if, and as the ordinary stock became valuable, it could be sold by the State and the money re-invested in new railway undertakings.

EIGHTEENTH ORDINARY MEETING.

Wednesday, April 27, 1898; Sir HENRY TRUEMAN WOOD, M.A., Secretary of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Carnegie, Douglas, M.A., 84, Shooters's-hill-road, Blackheath, S.E.

Cleghorn, Robert Cooper, 14, St. Mary-axe, E.C.

Davis, Harold, Belle-vue-house, Park-place, Greenwich, S.E.

Farmer, Henry, 5, Royal - terrace, Portishead, Somerset.

Skrine, Francis Henry, Queen Anne's-mansions, S.W. Smith, George Henry, Brooklands, New Malden, Surrey.

Stroud, Prof. Henry, M.A., D.Sc., Durham College of Science, Newcastle-on-Tyne.

Williams, Stephen M. J. (Bengal Nagpur Railway), care of Messrs. Grindlay and Company, Calcutta.

The following candidates were balloted for and duly elected members of the Society:—

Arthur, Allan, 7/1, Lyons-range, Calcutta, India.

Hodgkin, Thomas, Bank, Newcastle-on-Tyne.

James, John Herbert, 3, King's-bench-walk, Temple, E.C.

Lyon, Brigade-Surgeon-Lieut.-Col., Isidore B., C.I.E., 164, Sutherland-avenue, W.

Stevens, Henry W., 3, Hastings-st., Calcutta, India.

Storarr, David, Kirkcaldy, Fife, N.B.

The paper read was—

THREE-COLOUR PHOTOGRAPHIC PRINTING.

BY CAPT. ABNEY, C.B., D.C.L., F.R.S.

The Society of Arts has done me the honour to ask me to read a paper on three-colour printing by means of photography. I have responded affirmatively to the request for the reason that I am most obviously unbiassed by any external influences of trade secrets, and that I can approach it from a scientific side, and that I have no practical knowledge of any systems of trial and error, which are said to prevail in some classes of three-colour printing. After all, we theorists are not to be despised entirely by the practical man, for I need only allude to Mr. Ives to show you what predominant an influence science has had on some who felt the evil influence of rule-of-thumb work. When we have to deal with colours we have invariably, for theoretical purposes, to resort to—I nearly said fall back upon—the spectrum for inspiration as to how to proceed; and to-night I shall attempt to explain to you the theoretical basis on which three-colour printing ought to be worked. We have the spectrum on the screen, and we see that at first sight and without detailed examination it appears to be made up of red, green, and blue, which includes the violet. The other colours may be called incidental. It is this red, green, and blue

which, when mixed together in varying proportions, which give us any or all of the colours of nature. The colours are now recombined by means of a lens to form a white patch, and if we pass a slit through the spectrum, we get practically patches of monochromatic light on the screen. Passing a series of slits through the spectrum without interposing a lens, we get overlapping images of the face of the prism we are employing for analysing the electric light, and the overlaps show us that red and green make yellow, and blue and green, that greenish blue which is often called peacock green or blue, whilst blue and yellow make white. Replacing the lens it combines all the colours passing through the various slits, and we have a patch of mixed colours. If, instead of a multiplicity of slits, we have only three, we can obtain the same effects. We can multiply our colours and tones to any extent by opening more or less widely any or all of the slits. Instead, however, of altering the width of the slits, we may obtain the same effects by cutting off more or less light by means of photographic deposit on developed plates placed in front of the slits. This we do, and we see that we get colours of varying hues. Or we can cut off more or less light from the slits by rapidly passing in front of them apertures more or less widely apart. In fact, we can have a symphony of colour, and I show one which I recently prepared for a lecture at the Royal Institution. We can have various harmonies as it were by means of this arrangement. But I also wish to show that in order to produce these colours it is not essential to have any very pure colours, for I can withdraw the slits and let those parts of the spectrum which are opposite the three lines of apertures (holes) pass through, and they will combine, and we have still practically the same symphony of colour on the screen. We thus see that we may use a considerable part of the spectrum at three places and still obtain good effects of colour. Now, Mr. Ives has already in this theatre shown how he combines the light coming through coloured media to obtain his beautiful results, and I can here show you that by the use of media like his any colour of the spectrum can be obtained. By use of three glasses in a disc, and by cutting out suitable masks and then sending a slice of light through them whilst they are rotating, we have a very fair representation of the spectrum.

Thus every colour of the spectrum with a

fair amount of accuracy may be represented by the mixture of the light coming through these three glasses, if the intensities are properly arranged. So far, then, we have seen that by mechanical means we can obtain any shade or hue of colour. It now rests with us to see how we can utilise this scientific fact, to produce the colours as seen in nature by means of photography. Taking the spectrum colours we find that certain width of slits in the three colours—red, green, and blue, give white, if we cover up the blue slit we find that we have a yellow, if we cover up the green it is purple, and if the red it is a blue-green. If then, we have media of red, green, and blue, which allow the same relative brightness of these three colours to pass through, as do the slits in the spectrum; we readily see how a red, a yellow, a green, a blue-green, and blue, as well as white, are to be secured by means of three photographic positives. Suppose the problem before us as to how we should represent flat surfaces of these seven colours which have the same relative brightness as these spectrum colours on paper, how should we proceed? If we photograph them on three different plates, and take transparencies from them; and manage that the colours on each transparency are represented as follows (total transparency being represented by T, and perfect opacity by O)—

	No. 1 Plate.	No. 2.	No. 3.
White	T	T	T
Red	T	O	O
Purple	T	O	T
Yellow	T	T	O
Green	O	T	O
Blue-green	O	T	T
Blue	O	O	T

We shall find that if No. 1 be backed by a red medium, No. 2 by a green medium, and No. 3 by a blue, each of the right brilliancy to make a white when mixed, then the images when superposed would give the seven colours exactly. Again, suppose we had a dull yellow of half the intensity of the spectrum yellow—if in No. 1 and No. 2 plates the transparency were in each reduced to half (say)—then we should get the reduced yellow, and so on. We can form some idea of the way the three images when backed should look by an artifice that I have introduced for producing a monochromatic image. We can throw an image of the carbon points *on the prism* and the light after decomposition by the prism, and recombination by the lens outside the spectrum will form an image of the surface of the prism

upon the screen, and as this surface has an image of the carbon points upon it, the carbon points are seen on the screen. We may place three slits in the spectrum, and again we have the same (mainly) white image. By using three lenses instead of one we can project each coloured image separately and have them side by side. Instead of the carbon points we can place against the prism small squares of coloured glasses and we get the three images of these. The one corresponds to the transparency to be illuminated by the red, the next by the green, and the third by the blue. It is such transparencies that we must aim at obtaining. Now I need scarcely say that a negative taken through a red medium, and second through a pure green medium, and the third through a pure blue medium would not be effective. Think of what a spectrum on the screen would look like if thus photographed. One negative would give a transparency which would only allow a narrow band of red to show, the next of green and the next of blue, and thus the spectrum would be represented by three bands of colour simply. There would be no over-lapping of colours to show the intermediate colours. It is evident that we must obtain media which would allow more of the spectrum to pass through in order to obtain an overlap.

Quite recently at the Camera Club, I have brought forward a colour sensitometer to enable a plate to be tried for the three colours most suitable to use as taking screens. The principle on which this is designed is as follows:—Take a number of small coloured squares of glass such as enumerated above, which only allow certain colours to pass through. Choose the three colours with which the three transparencies are to be backed, and by mixture of these standard colours find out how much of each of them is required to match the colours of the glasses both in intensity and hue. Measure the brightness of the light coming through the coloured glasses. Then to make a sensitometer to enable you to choose the proper screen for taking the “red negative,” as I will call it, reduce the brightness of the different glasses to the extent which is necessary to cause all the red light required to come through the different colours to be of equal intensity. Then in a proper negative all of the deposits should be of equal opacity, and for any brand of plate used a screen must be sought for which will give this result. Take another similar set of glasses and reduce the transmission of them so that the

green transparency should allow equal light to penetrate, and a screen must be sought for till such is the case. The same for the blue. We thus shall have found three screens through which to photograph to give us three transparencies from the three negatives that when backed with the chosen colours red, green, and blue, will give us the true colours of the objects. This sensitometer, I hope, may prove of use in the future to those who are doing three-colour printing.

I am not to have the privilege of showing you Mr. Ives' work to-night, so far as three combined images are concerned, because he has shown you them himself on a previous occasion; but I am allowed to show you what is a modification of it, viz., Joly's process. Dr. Joly obtains only one negative, but that negative really contains three. In contact with the plate he places a screen ruled in three colours with lines $\frac{1}{16}$ of an inch broad, and touching one another. One line answers to the red-taking screen, another to the green, and the third to the blue. (In front of the lens he places a coloured medium to tone down the blue.) The plate is exposed through this screen, and as a result he obtains the red, the green, and the blue negative intermingled one with another, each being represented by one-third of the surface. From this a transparency is made, which is backed by another ruled surface of red, green, and blue lines of the same width, and proper intensities. The red lines fall on the portions which were taken through the “red taking” lines, the green on the green, and the blue on the blue, so that we have a coloured representation of the objects, and very beautiful they are. We can show you a taking screen, a viewing screen, a negative, a positive, and a positive backed by the ruled screen, and that will give you the process. (Slides were here shown of various coloured objects.)

We have now led up to the question of photographic printing in colour, not by mixing the light coming through three separate transparencies, but by the use of transparent colours and using the negatives from which to obtain coloured images. This is really a question of absorption of light, and depends on exactly the same principles as have been just enunciated for the mixture of light from three images. We may take it that the colours suitable to back the positives must form the basis of any process; but we shall see that the colours to be used are exactly complementary colours to the three fundamental monochromatic colours of red,

green, and blue. A complementary colour, be it remembered, is that colour which with the original will give a white.

Reverting to the spectrum, we place the three slits in it and once more form white light. The red and the green and the blue are now in proper proportions. If we cover the red slit up, we have a blue-green formed, and that is the colour with which we must print from the red negative. When the green slit is covered up we have a pink or purple, and that is the colour to be used with the green negative, and a bright yellow similarly is derived from covering up the blue slit, and is the colour that must be used with the blue negative.

These, be it remembered, are exactly the complementary colours of the fundamentals, and the nearer we can imitate these the more correct we shall be. If we pass an opaque strip along the spectrum we shall see we have the complementary of the colour blocked out, but in this case if the strip be very narrow the complementary will be too white. The criterion as to the suitability of the colours in regard to purity is that when two colours are superposed the resulting colour should approximately equal in hue and purity the fundamental colour. Here I have, thanks to Mr. Warnerke, several graduated annuluses of gelatine coloured with pink, blue-green, and yellow. I place them in the spectrum, and we see that we have a fairly large portion of the spectrum transmitted through all, though in different positions and overlapping. (The transmission of a small band of red through the blue-green is a misfortune, though it counts but little in reality.) Placing the pink and blue-green together and sending the light through them both we see that we have a fair blue. With the pink and the yellow together we have a good red, and with the yellow and the blue-green together we have a good green. These colours match very fairly Mr. Ives's standard colours, which should not be widely departed from for practical purposes. We may take it then that these particular hues that I have shown are not far off theoretical correctness.

Now why have we to print the red, green, and blue negatives with these complementary colours to obtain a print in colour?

Let us take the instance of a white object. Here each of the three negatives would show the white as opaque deposit, consequently when printing each of them on some sensitive surface coloured with these complementary colours there would be a blank on each, and if

the three images were superposed on white paper there would be no colouring matter from any of them. Let us take a red object. Here the red negative would show the object as opaque, whilst the green and blue negatives would show it as totally transparent. If the green negative be printed on a sensitive surface and coloured with pink, we should have for the red object a full pink, and if the blue negative were printed with a yellow we should have it a full yellow. When the two transparent but coloured films are superposed we should have a yellow film lying over a pink film, and as we have already seen the light penetrating would be a red. Once more, let us take a bright yellow. Here our table shows us that we shall have total opacity in the red and green negatives (since in the transparencies they have to be shown as totally transparent). Consequently, the only negative which when printed on the appropriate sensitive surface is the blue, and that we have to print in yellow. Hence, we have the object shown in yellow on the white surface. Mr. Ives has shown this fact in making lantern slides by this method. He prints on bichromated gelatine, and then dyes his three prints with the appropriate complementary colours and superposes them. Of this method he has kindly lent me a few specimens. What answers for the lantern slide will also answer if the films are placed on paper. This would be photographic printing; but the same principle applies to blocks. Suppose a typo-block is prepared from the red, green, and blue negatives by any of the various processes, and that the block from the red negative is worked in with transparent blue-green ink, that from the green negative with transparent pink ink, and that from the blue with transparent yellow ink, and that these separate impressions are superposed with accurate register. Then we have a mechanical method of printing in colours. This is the theory of the matter, and all practice must eventually be derived or come to it. There are several firms who work in these directions, and no more beautiful work has been done than by Messrs. Waterlow, who have kindly allowed me to show some specimens of their work. The *Graphic* send specimens of their three-colour printing, and also Messrs. Cassells, and excellent work it is.

Mr. Warnerke informs me that in Russia a machine has been perfected which allows the three inks to be distributed uniformly over each block, and that each block prints on to a hard surface, the registration being made in

the most perfect manner. When the three inks have been printed on the fixed block, this ast is brought in contact with the papers, and the impression is pulled at one operation. Mr. Warnerke has kindly lent me slides illustrating this, and shows photographic prints produced by the same machine. Such a process as this should be able to give results not only with transparent inks, but with opaque inks, where the colours are obtained by dots of the three fundamental colours placed side by side. More, probably, may be heard of this process by and by.

[Specimens illustrating the process of three-colour printing were lent by Messrs. Cassells and Company; the proprietors of the *Graphic*; Mr. Leon Warnerke; Messrs. Waterlow and Sons, and Messrs. Husnik and Hausler, of Prague (through Mr. F. C. Clarkson).]

DISCUSSION.

The CHAIRMAN, in inviting discussion, said Captain Abney had well explained the principle on which photography in colours was carried out, and there were few more interesting applications of science than that of photography to colour printing. They all knew the ordinary chromolithograph, in which a separate stone had to be prepared for every colour, or nearly every colour, which the artist had employed in his picture, and by successive printings on the same piece of paper the effect was produced. Some very beautiful pictures were produced in this way, and it was rather the pride of the chromolithographer to say how many stones a particular print had taken, and to show his skill in obtaining accurate register, so that all the colours fitted exactly into their proper positions, with no overlapping and no thin white lines where the colour did not appear. One of the chief things which Captain Abney had shown was that all the colours and tints of Nature could be produced by combinations of three colours only, and it was an obvious simplification of the process to reduce the numerous printings to three. The pictures kindly lent by the *Graphic* were interesting illustrations of this fact; being all produced from three colours, which were selected according to the skill and judgment of the worker. This process, however, was only used occasionally, the greater part of their work being still done by the ordinary process of chromolithography. He was informed that there were very few operators on the staff of the *Graphic* sufficiently skilful to select the three tints and lay them out on the stones so as to produce by their combination the finished pictures such as those exhibited. By means of photography this was done automatically. Now it was, apparently, a very simple matter by filtering out the different colours from white light, applying the proper screens to divide up

the white light into three such portions that you could produce three printing surfaces—stones or blocks—which, by their combination, would give all the colours of the original, but in practice it was a very difficult matter. It was a good many years since they first heard that someone had succeeded by this process, in obtaining, more or less, good results; but it was only lately, thanks to the researches of the gentlemen to whom Captain Abney had alluded, Mr. Ives, and others, not omitting Captain Abney himself, that such knowledge was gained as enabled the theory to be reduced to practice. He was sorry that none of Mr. Ives's work had been shown that evening, though it had been exhibited there before. It was in that room that Mr. Ives showed the results of his work when he first came from America, and more than once they had had the advantage of seeing there the results of his perfected researches, but still he regretted that through an accident they had no specimens that evening. He, however, congratulated the members on having had for the first time the opportunity of seeing some of the very beautiful results of Dr. Joly's work. It was rather remarkable that, although from the birth of photography, the dream of its followers had been to produce photographs in colour, and some of the earliest workers did do something in that direction, so little advance had been made in this direction. The only man who really had obtained a photographic picture in natural colours was Professor Lippmann. He produced a photograph which, when white light was thrown upon it, with proper precautions, reproduced the colours of the original. Others, like Mr. Ives and Dr. Joly, relied on coloured media: they did not use the real spectrum, but that imitation spectrum which had been shown that evening, and to reproduce a spectrum by means of properly selected coloured media, was, in itself, no small feat. It was by such means that the beautiful results of Mr. Ives and Dr. Joly and others were produced. That was not photographing in colours: it was viewing a photograph by means of coloured media in such a way as to reproduce the colours of Nature. In the same way three-coloured printing was not the natural reproduction of colour by photography, but the careful selection of colours by photographic means so as to produce, more or less, the same appearance as the colours of Nature. He hoped Mr. Warnerke would be kind enough to give some further information about the ingenious Russian invention which had been mentioned. As he understood, the principle of it consisted in using three blocks for printing three colours, but instead of printing from those blocks direct on to the paper in succession, each block transferred its ink to a separate roller, and from that roller the three different coloured inks were again transferred to one single block from which the impression was taken on the paper. The mechanical devices for accomplishing this were complicated and difficult, but when they were overcome there was no difficulty about register as the whole thing was printed at once.

Mr. L. WARNERKE said the principle of the machine had been so clearly described by Sir Henry Wood that he had very little to add. It was invented not long ago but had already superseded all other machinery in the State paper manufactory in St. Petersburg; as it had so many advantages over ordinary machines used for colour printing. In the ordinary way separate blocks had to be used for each colour, and after one colour had been printed it had to dry before the second could be printed, and so on, and that made it very difficult and in fact almost impossible to get perfect register on account of the different hygroscopic conditions of the air, differences in temperature, &c.; especially when very fine engraving, such as had been shown on the screen was in question. In this case there was a rotary machine with a large cylinder, on which there was a separate *cliché* for each colour with separate ink ducts, so arranged that by one revolution of the cylinder, each *cliché* was inked with its appropriate ink. These inks were transferred to one large composition roller, which in its turn inked the *cliché* which printed the sheet. There were very perfect arrangements for putting the paper into the machine and for removing it, interleaved with plain sheets to prevent smudging. The peculiarity of the rosette patterns which had been shown, and which were specially applicable to cheques and bank notes, consisted in the fact that the very finest lines passed from one colour to the other without the slightest break or fault in the register, and of course an enormous variety of designs could be produced by applying different coloured inks. On the wall were shown impressions produced from a three-colour photographic block. For bank notes sometimes four or five colours were used, but for photographic colour printing there were sufficient blue, yellow, and red. The advantages of this method were very great. If one examined carefully some of the finest colour prints produced in the ordinary way from separate blocks, one would find a sort of *moiré* appearance which was entirely absent when this new machine was used. The photographs which had been shown were taken on the spot under some difficulty, and he might say that some fifty of these machines had been at work for the last two or three years.

Mr. F. E. IVES said Captain Abney had presented the subject in so admirable a manner that he should not be justified in taking up time by attempting to elucidate it further. He would only apologize for the absence of any illustration of his own work by saying that it was purely accidental. Specimens had been selected and addressed to Captain Abney, and where they had gone to he could not tell. As the Chairman had said, it was of the less importance, as they had been seen before.

The CHAIRMAN said if no one else had any remarks to offer he must propose a hearty vote of thanks to Captain Abney for his paper. There could be no

greater treat to anyone interested in these subjects than to see Captain Abney manipulating the spectrum, because he had a wonderful gift of demonstrating in a practical and lucid manner scientific problems of great complexity and difficulty. That was the great advantage of hearing a lecture in that room. People might read Captain Abney's papers in the "Philosophical Transactions," or his more popular handbooks, but they could not adequately appreciate the phenomena described unless they saw the actual experiments which Captain Abney was so competent to place before them.

The vote of thanks having been carried unanimously,

Captain ABNEY, in reply, said he had no doubt that when this paper found its way abroad it would be severely criticised in certain quarters, but he did not mind that, as he was perfectly certain that the principles which he had enunciated were correct.

Miscellaneous.

ANCIENT AND MODERN INKS.

It is frequently stated that since the Mediæval ages the art of ink-making has shown decided signs of retrogression, and, as evidence of this deplorable fact, mention is made of certain documents written six to eight centuries ago which, when compared with many writings of less than a hundred years of age, show far greater legibility, and a more perfect degree of preservation.

It is probable, however, that the inferior ink has come into use during the last few centuries, not so much through ignorance concerning the manufacture of more permanent ink, as through the desire to employ an ink which would not deteriorate by settlement, and which would, by more perfect fluidity, be more conducive to rapid writing than the ancient inks.

Vitruvius, Pliny, and Dioscorides each mention ink as containing soot or lamp-black mixed with some mucilaginous fluid, and, although even in their day a dye was also sometimes added, there appears to be little doubt that the legibility of ancient records is due to the use of carbon as the basis of the ink; and that when, towards the close of the Mediæval period, the element carbon began to be disregarded altogether as an ingredient of ink, the fading of manuscripts became more rapid.

Many years ago an ink receptacle was found at Herculaneum which contained a small quantity of ink. Upon examination this proved to be composed simply of lamp-black mixed with a thick oil, and it is supposed that this is the description of ink which was used for writing upon papyri at the time of the destruction of Herculaneum.

Such ink must have required frequent stirring, and the writing was probably performed with a fine brush. "The lamp-black," says Underwood, "was ground up with the oil as painters' colours are now done, and by remembering this, we can understand the meaning of Demosthenes when, in a speech of his, he taunts his great rival, Æschines, for having being compelled in his youth, through poverty, to sweep the school, sponge the benches, and grind the ink."

The rapidity with which carbon settles out from the liquid in which it is suspended, and the poor fluidity of a mixture of carbon and mucilaginous liquid, prohibit its use for modern commercial purposes; there is evidence also that writers in the early centuries endeavoured to replace it by some more convenient substance, for Thomas Astle, the author of *The Origin and Progress of Writing*, originally published towards the close of the last century, mentions that he possessed a parchment roll requesting prayers for the Countess of Oxford, who died in 1199; this roll contains certificates from many of the religious houses, flourishing in England at that time, and it is observed that whereas some of them are as black as if recently written, others are brown, and some of a yellow hue.

The extract of gall-nuts, or other tannin matter, in combination with an iron salt, which forms the basis of most black writing inks of the present day, was in use many centuries ago, but it appears to have at first been mixed with soot or lamp-black, which, however, seems to have gradually been discarded. The blue-black inks of the present day consist generally of this tannate or gallo-tannate of iron suspended in water containing gum, and mixed with indigo or some similar colouring matter.

Coloured inks, consisting probably of vegetable extracts, were known to the ancients. The coloured inks of to-day are frequently simple solutions of aniline dyes; but logwood and other vegetable dyes are still used to a considerable extent. A somewhat remarkable production of the present age is the preparation of a fireproof ink with a platinum salt for its basis, to be used in conjunction with a fireproof paper composed largely of asbestos.

Before leaving the subject of writing-inks, mention must be made of the changes which have taken place in the manufacture of paper during modern times, for the quality of the paper largely influences the permanency of the ink. The parchment skins which were formerly used for writing upon were far superior to our modern paper, so far as preservation of the written record is concerned; even the old unbleached paper was superior to the modern bleached and glazed material, for small quantities of chlorine and lime always remain in the paper, and apparently exert a detrimental effect upon both paper and ink in the course of time. The result of using wood pulp for paper making may already be seen in many books, in which the paper has turned to a brown colour, and become so brittle that it may

be broken into small pieces by merely crumpling in the hand.

The ink in use at the present day by the draughtsman for drawing purposes appears to be very similar to that formerly used for ordinary writing purposes. In this country it is most commonly known as "Indian ink," although it appears to be most extensively manufactured in China, several factories for preparing the ink being in existence at Shanghai and other parts of the Chinese empire. To this day it is often used as a writing ink in China, Japan, and other Asiatic countries, a small brush taking the place of a pen.

This ink is merely a mixture of carbon and gum with the addition of a small quantity of musk, or Borneo camphor, to give it the characteristic peculiar odour. But the preparation of this simple ink is by no means easy, for unless the materials are of the finest quality and the carbon as finely divided as it is possible to obtain it, an inferior ink will result. At the same time, there are no extraordinary properties about genuine Chinese ink, as Europeans have been able to manufacture ink equal in quality, if not superior, to that which comes from the Far East. The chief drawback to European ink is that the European manufacturer is apt to seize upon the first opportunity of substituting cheaper raw materials, whereas the tendency of Chinamen is to remain *in statu quo* throughout eternity.

After the carbon and gum have been mixed, the product has to be slowly and carefully dried. The moulding of the sticks is effected in moulds engraved on the inside with Chinese characters, such as the well-known dragon, &c., and the gilding is performed with gold-leaf. The high polish of the sticks is said to be produced by brushing them with a hard brush impregnated with tree-wax. A good sample of Chinese or Indian ink is fine-grained and homogeneous throughout, does not deteriorate with age, and will produce lines of perfect regularity of tint.—*The Builder*.

Notes on Books.

A SIMPLE GUIDE TO THE CHOICE OF A PHOTOGRAPHIC LENS. By T. R. Dallmeyer.

Of the thousands of photographers who are constantly using lenses, but very few probably have any knowledge of the principles on which so familiar a piece of apparatus works, its merits or its defects. Mr. Dallmeyer's pamphlet is an effort to explain, in the simplest possible language, and without the use of mathematical symbols or formulæ, the optical principles which govern the construction and use of photographic lenses. Why some lenses are "slow" others "rapid," why some are classed as

"wide angle," the meaning of "depth of focus," "astigmatism," "flatness of field," "spherical elevation;" these and similar questions are answered in simple language, and explained by numerous diagrams.

SOLDIERING FIFTY YEARS AGO: Australia in the Forties. By Major de Winton. 1898. *European Mail*.

Major de Winton's experiences lay principally in Australia, and he is consequently able to record many interesting reminiscences of the early days of the colonies. He went out with a detachment in charge of a convict ship, and his duties in Australia were principally in connection with the convicts. At one time he was stationed at Norfolk Island, so that he is able to speak with authority on the results of transportation. His view is certainly more favourable than that of other more sensational writers, and his accounts of convict life are more satisfactory than those which are generally prevalent. He also bears testimony to the value of the services of the officers who discharged duties never pleasant, and often onerous and difficult.

General Notes.

MINES AND QUARRIES.—The output of coal in the United Kingdom for the year 1897 was as follows:—England, 143,477,127 tons; Wales, 29,424,048 tons; Scotland, 29,082,996 tons; Ireland, 135,025 tons; making a gross total of 202,119,196. The output of fireclay was:—England, 1,734,086 tons; Wales, 213,535 tons; Scotland, 726,951 tons; Ireland, 7,900 tons—gross total, 2,682,472 tons. Of oil-shale:—England, 10,580 tons; Wales 1,560 tons; Scotland, 2,211,617 tons—gross total, 2,223,757 tons. The total number of persons employed in mines and quarries in the United Kingdom, is 695,213 (558,305 below ground, 136,908 above ground).

ART METAL EXHIBITION.—An Exhibition of Art Metal Work will be held at the Royal Aquarium from the 27th May to 30th June. St. Stephen's Hall, possessing a separate entrance and with an area of 50,000 square feet, and the south gallery are allotted to the reception of the loan collection of ancient armour and fine metal work. The galleries will be screened from the rest of the building by oak and tapestry. The main portion of the Exhibition, comprising the Industrial section, will be held in the north gallery and the arena. The Concert-hall is to be given up to competitions of craftsmen and their apprentices. The last comprehensive display of modern metal craft seen in London was in 1862, and the last important loan collection of ancient metal work was shown at the Ironmongers' hall a few years later. The Hon. President of the present Exhibition is the Duke

of Westminster, K.G., and the Hon. Vice-President is the Marquis of Lorne, K.T. The Hon. Secretary is Mr. J. Starkie Gardner.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock:—

MAY 4.—"The Revival of Hand-loom Weaving." By MISS CLIVE-BAYLEY. Sir GEORGE BIRDWOOD, K.C.I.E., C.S.I., will preside.

MAY 11.—"Water Gas and its Applications." By Professor VIVIAN B. LEWES.

MAY 18.—"The Evolution of the Cycle." By J. K. STARLEY. C. V. BOYS, F.R.S., will preside.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock:—

MAY 19.—"Chartered Companies and Colonisation." By Sir ALFRED COMYNES LYALL, G.C.I.E., K.C.B., D.C.L. (Member of the Council of India). HENRY M. STANLEY, M.P., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday afternoon, at 4.30 o'clock:—

MAY 24.—"The Goldfields of British Columbia." By W. HAMILTON MERRITT. Sir CHARLES MALCOLM KENNEDY, K.C.M.G., C.B., will preside.

APPLIED ART SECTION.

Tuesday evening, at 8 o'clock:—

MAY 3.—"Senefelder and the Centenary of Lithography, 1798-1898." By JOSEPH PENNELL.

MAY 10, AT 4.30 P.M.—"The Art of William Morris." By F. S. ELLIS.

CANTOR LECTURES.

Monday Evenings, at Eight o'clock:—

PROF. CHARLES A. CARUS WILSON, M.A., M.Inst.E.E., Professor of Electrical Engineering, McGill University, Montreal. "Electric Traction." Four Lectures.

LECTURE I.—MAY 2.

The action of a motor—How to find the force for a given current—Relation between force and power—Conditions of uniform motion—Speed and torque curves—Series winding—Variation of speed with load and tension of line—General description of a railway motor—Relation of motor torque to draw-bar pull—Design of equipment for given output.

LECTURE II.—MAY 9.

Acceleration—Conditions under which a train is started—Method of drawing acceleration curves—Uniform and variable acceleration—Example—The City and South London Railway—Control—Com-

parison of different methods—How to ensure a smooth start—The series-parallel controller—Example—The Liverpool Overhead Railway—Different ways of handling the controller—Example—The Buffalo and Niagara Falls Electric Railway—Effect of the slipping of the driving-wheels.

LECTURE III.—MAY 16.

Energy diagrams—Sub-divisions of energy expenditure—Case when final speed is fixed—Possible ways of reducing the expenditure—Effect of series winding is to reduce the heat loss—Highest economy limited by the weight of the motor—How to find the best values of gear-ratio and driving-wheel diameter—Example—The Baltimore and Ohio Railroad—Effect of reduction in train resistance—Use of roller bearings.

LECTURE IV.—MAY 23.

Case when the final speed is not given—Design for covering a given distance in the shortest time for a given current—Time curves—Effect of using driving-wheels of different diameters—Design for covering a given distance in a given time, with the least possible expenditure of energy—Influence of the weight of the motor on the economy—Advantage of gearing—Example—The Chicago Metropolitan Elevated Railroad.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 2 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. Carus Wilson, "Electric Traction."

Farmers' Club, Salisbury-square Hotel, Fleet-street, E.C., 4 p.m. Mr. J. F. Beddall, "Dairy Farmers—their Difficulties and Requirements."

Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting.

Engineers, in the Theatre of the United Service Institution, Whitehall, S.W., 7½ p.m. Adjourned Discussion on Dr. Thresh's paper, "The Protection of Underground Water Supplies."

Chemical Industry (London Section), Burlington-house, W., 8 p.m. Dr. W. Hampson, "Self-intensive Refrigeration of Gases, Liquid Air and Oxygen."

Surveyors, Savoy-street, W.C., 8 p.m. Adjourned Discussion on Mr. H. M. Grellier's paper, "Tithe Rent Charge Recovery," and on Mr. Thomas Blashill's paper, "Lessons from Fire and Panic."

British Architects, 9, Conduit-street, W., 8 p.m. Annual Meeting.

Victoria Institute, 8, Adelphi-terrace, W.C., 4½ p.m. Prof. Hull, "British Submerged River Valleys."

TUESDAY, MAY 3 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Applied Art Section.) Mr. Joseph Pennell, "Senefelder and the Centenary of Lithography, 1798-1898."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. S. R. Gardiner, "The Historical Development of Europe." (Lecture I.)

Central Chamber of Agriculture (at the House of the Society of Arts), 11 a.m.

Society of Designers, Clifford's-inn, E.C., 8 p.m. Mr. E. Foley, "Design for Furniture and other Woodwork."

Pathological, 20, Hanover-square, W., 8½ p.m.

Biblical Archaeology, 37, Great Russell-street, W.C., 8 p.m.

Zoological, 3, Hanover-square, W., 8½ p.m. 1. Sir H. H. Johnston, "Remarks on the Larger Mammals of Southern Tunisia." 2. Prof. Robert Collett, "Some Pigeons and Parrots from North and North-West Australia." 3. Dr. W. T. Blanford, "Notes on Two Hares, *Lepus oisotolus* and *L. pallipes*, from Tibet, and on a Kashmir *Macacus*." 4. Messrs. F. A. Dixey, M. Burr, and O. Pickard-Cambridge, "A Collection of Insects and Arachnida made in 1896-97 by Mr. E. N. Bennett in Sokotra, with Descriptions of New Species."

WEDNESDAY, MAY 4 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Miss Clive-Bayley, "The Revival of Hand-loom Weaving."

Geological, Burlington-house, W., 8 p.m.

United Service Institution, Whitehall, S.W., 3½ p.m. Major F. N. Maude, "Economical Army Reform."

Archaeological Association, 32, Sackville-street, W., 4½ p.m.

Obstetrical, 20, Hanover-square, W., 8 p.m.

THURSDAY, MAY 5 ... Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Sir John Lubbock, "Some Spitzbergen Collembola." 2. Miss Ethel Barton, "The Structure and Development of *Soranthera*." 3. Mr. J. T. Cunningham, "The Species, the Sex, and the Individual."

Chemical, Burlington-house, W., 8 p.m. 1. Messrs. C. F. Cross, E. J. Bevan, and Claud Smith, "The Reactions of the Carbohydrates with Hydrogen Peroxide." 2. Mr. H. J. H. Fenton, "The Properties and Relationships of Dihydroxytartaric Acid. Part II." 3. Mr. S. Skinner, "The Affinity Constants of certain Hydroxy-acids." 4. Mr. J. Murray Crofts, "Molecular Weights in Solution of Permanganates, Perchlorates, and Periodates."

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Sir Wyke Bayliss, "The Likeness of Christ from the 1st to the 19th Centuries."

Royal Institution, Albemarle-street, W., 3 p.m. Rev. Canon Ainger, "Some Leaders in the Poetic Revival of 1760-1820." (Lecture III.)

Iron and Steel Institution, 25, Great George-street, S.W., 10½ a.m. Annual Meeting. Reading of Papers and Discussions.

FRIDAY, MAY 6 ... Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Mr. Edward A. Minchin, "Living Pictures."

Iron and Steel Institution, 25, Great George-street, S.W., 10½ a.m. Annual Meeting. Reading of Papers, and Discussions (continued).

Geologists' Association, University College, W.C., 8 p.m. 1. Mr. Horace B. Woodward, "Notes on Skye." 2. Mr. Aubrey Strahan, "Observations in Lapland."

Junior Engineering, Westminster Palace Hotel, S.W., 8 p.m. Mr. Harry Fraser, "Evaporative Condensers, and Independent Air-Pumps for same."

Philological, University College, W.C., 8 p.m. Annual Meeting.

Quekett Microscopical Club, 20, Hanover-square, W.C., 8 p.m.

SATURDAY, MAY 7 ... Botanic, Inner Circle, Regent's-park, N.W., 8½ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Sir Walter Parratt, "Progamme Music." (Lecture III.)

Journal of the Society of Arts.

No. 2,372. VOL. XLVI.

FRIDAY, MAY 6, 1898.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****CANTOR LECTURES.**

On Monday evening, 2nd inst., Professor CHARLES A. CARUS WILSON, M.A., M.Inst. E.E., delivered the first lecture of his course on "Electric Traction."

The lectures will be printed in the *Journal* during the summer recess.

APPLIED ART SECTION.

Tuesday, May 3, 1898; LEWIS FOREMAN DAY, Member of Council, in the chair.

The paper read was "Senefelder, and the Centenary of Lithography, 1798—1898," by JOSEPH PENNELL.

The paper and report of the discussion will be published in a future number of the *Journal*.

PRACTICAL EXAMINATIONS IN MUSIC.

The Practical Examinations in Vocal and Instrumental Music will be conducted by Mr. John Farmer, Balliol College, Oxford, and Director of the Harrow Music School, Examiner, and Mr. Ernest Walker, M.A., Mus.Bac., Oxon, and Mr. Burnham Horner (organ), Assistant Examiners, at the House of the Society, and will commence on Monday, 27th June.

The last day for receiving applications is Saturday, 14th May.

Particulars can be obtained on application to the Secretary.

Proceedings of the Society.**NINETEENTH ORDINARY MEETING.**

Wednesday, May 4, 1898; Sir GEORGE BIRDWOOD, K.C.I.E., C.S.I., M.D., Vice-President of the Society, in the chair.

The following candidates were proposed for election as members of the Society:—

Greg, Arthur, Eagley, Bolton.

Jacobson, Nathaniel, Olive-mount, Cheetham-hill-road, Manchester.

Yong, William, Town-hall, Salford.

The following candidates were balloted for and duly elected members of the Society:—

Callan, William, 2, Coleman-street, E.C.

Cory, John, J.P., D.L., 4, Park-crescent, Regent's-park, W., and Duffryn, Cardiff.

Gray, Matthew Hamilton, Lessness-park, Abbey-wood, Kent.

Johnson, Henry Luttmann, Alenho, Ridgeway, Wimbledon, S.W.

Kingdon, G. H. K., 47, Lovely-lane, Warrington.

McKeone, Henry, 18, Addison-gardens, W.

Madho, P. Beni, Jodhpur, Rajputana, India

Mathers, Edward Peter, Glenalmond, Beckenham, Kent.

Riley, Lionel Vincent, 10, Throgmorton-avenue, E.C.

Walker, James Lewis, 178, Queen's-gate, S.W.

Watts, Philip, Elswick Shipyard, Newcastle-on-Tyne.

White, James Martin, Balruddery, New Dundee.

Wood, John Alfred, Kenmore, New Eltham, Kent, and 2 Coleman-street, E.C.

The paper read was—

THE REVIVAL OF HAND-LOOM WEAVING.

By MISS CLIVE-BAYLEY.

Poetry and music thrive best, it is true, in the forest and in the moorland, where no coal smoke adds lurid glory to the sunset, nor sullies the heavenly purity of the air. Out on the lonely mountain sides the laboured breath of steam, the clang of mighty engines, are unknown, and there is little wonder that the dwellers in those parts catch instead the footfall of phantom deer, the passing of those "who are not," and of the many wondrous beings who people alike the imagination and the literature of primitive nations. It needs but little poetic instinct to revel in the silence of the forest. To catch the meaning of that silence, and to give it voice, is the inborn impulse of a child cradled by Nature, and taught in tongues which are too acute or too deep for ears dulled by a city's din. It is natural that the poetic fancy should intertwine itself with the occupations of home life, with the employments and crafts learnt at a mother's knee. Hence the runes of the Kalewala are rich in imagery connected with the trade of spinning and weaving, and when Wainominen,

old and noble, is asked whence he got his songs, he says he gathered them from the forest, from the spring grasses, from the budding hedgerows, from the song of birds, and from his mother's wheel.

It requires a genius of quite another order to understand the throbbing vitality of a vast factory, pulsating with an energy which, though it is not human, is nevertheless the translation into very forcible prose of man's highest faculties—imagination, invention, creation. One must isolate oneself in that clanking wilderness of noise before one can realise that it is human intellect which lit the match and fused into active combination the latent forces of inert matter.

It requires only a moment's concentration of thought, most necessary in those who deem it possible that hand-weaving can ever supersede machine-weaving, to realise that it is precisely to these two inert masses, coal and iron, in steam and machinery, that we owe the phenomenal prosperity and ascendancy of British trade. The history of the Victorian era is the history of expansive force and multiplied energy—of enterprise carried on the breath of steam, of energy manifolded by machine power; and it is only by this just appreciation of the scope of machine work—of its purpose and its significance—that we can in any degree grasp the situation suggested in the words, “the revival of hand-loom weaving.” Much of the sentiment which hangs over hand-work *versus* machine-work is a cloud of incense, sweet but bewildering, which too often hides the shrine of truth, or dulls and enervates the understanding. I have heard a wish expressed that the followers of him who first lit a coal fire in London had been hanged, as he was, for polluting God's air; and for many years the cry of Devildust and his companions, as for the “rights of labour, the people goes for nothing with this machinery,” was echoed by thousands who found their occupation gone. But so changed is the present aspect of affairs that the *Textile Mercury* and Yorkshire papers congratulate their machine hands that the present revival of spinning is not likely to interfere with their trade, nor come into competition with the machinery which has established so overwhelmingly an ascendancy in our country. The rights of labour have shifted; the machinery is its bulwark, and not its bane.

To deal, however, exhaustively, or even comprehensively, in one short paper with all the different interests which merge themselves

in the subject of hand-weaving and its revival, is difficult if not impossible. It needs but a moment's thought to realise how such a topic is fraught with difficulty; how it deals with burning questions of the hour; how politics, social problems, education, trade and commerce, colonial interests, and foreign affairs, are intimately affected by any such revival of an almost extinct industry, should it pass the limits of a woman's fashion or a parish council-room.

So much æstheticism and even socialism has been talked about the question, that it is not easy to divest one's mind of a prejudice against, or a tendency to overestimate the movement, or to balance the reasons for and against such a revival with a calm and unbiassed commonsense.

The mere word revival leads us to remember that there was a time when hand-weaving was all in all, that its very supremacy gave birth to its competitor, and that its revival, if it lasts as we all trust it may, must be founded not on the death or decay of machine-weaving, but on a higher plane of superior workmanship, of quality as against quantity, of educated and delicate handicraft against precise but automatic skill.

We are told that the trade of our country is on the decline; that with an increasing population we have a diminished number of artisan and industrial work-men and women; that, owing partly to the foresight and educational system of Germany, Belgium, and Switzerland, the monopoly of power-loom weaving is passing from us; that with us, as with Spain when she became the bullion dealer of the world, the industrial arts are dying strangled by that scorn of labour which is the precursor of industrial ruin. But prophets who prophesy wisely give always a loophole for the falsification of their words, and if we repent us of our indolence, our insolent neglect of that marvellous instrument of production which marks us off from the brute creation, we may yet turn the tide of ruin, and save the credit and industrial life of our country. It is chiefly to women that the nation looks for works humble in nature but significant and potent in results. The rights of women are established, and among them the one we chiefly appreciate is the right to work, and to those who desire to use that right, there is no difficulty in obtaining an opportunity to do so.

Now on the face of this question, it is self-evident that where quantity is concerned, the power-looms can turn out millions of yards

of calico and of cheap goods, which it would take years for hand-loom to accomplish; and, therefore, no reasonable person would venture to suggest competition with this unskilled toil.

But there is no doubt that while machines are thus making us in one sense realise that time is money, and that every moment can be calculated at so much per yard, we have, as it were, displaced the balance of time, made so infinitely valuable in the factory and workshop, that we have there to put time limits, while in the cottage there is a glut of it, and in the homes of the educated classes there is too often so much time on hand that numerous devices have to be taken in order to kill it.

The women of England have had a surfeit of idleness, are weary of practising unending scales, exercises, and light music, on the ever-cheapening and what are really now cottage pianos; are sensible that rummage sales, fancy bazaars, and crazy patchwork are not the whole soul and business of life, and that missing word competitions, double acrostics, and even golf, bicycles, or croquet, are not sufficient to satisfy their activities and their restlessness.

Those who have turned what would otherwise have been their unused energies in the direction of charity organisation, work on public bodies, such as School Boards, as officials or school managers, and guardians, know how great is the same want of occupation among the poor. Machines have taken away a great proportion of the work which made cottage women busy. These latter spin not, they weave not, they make not, they mend not, and the bakers, soup kitchens, and schools take away the other occupations of baking, cooking, and looking after their children, which used to form so important a feature in their lives. There is, no doubt, somewhere or other, a plethora of washerwomen and charwomen, but one always fails to find them, and the usual cry of women in their homes is the dulness and lack of interest, which necessitates amusement, either in the milder forms of village gossip, or, in some sad homes, of novel reading, drinking, and even gambling. Now it is just this waste of valuable time, of still more valuable human labour, energy, and intelligent activity, which places us at a manifest disadvantage with our competitors abroad. There is nothing more terrible than to go on a foot journey round some of what once were our most industrious villages, and ask, "What is your occupation?—how do you employ your time?" No; their mothers worked lace, their grandmothers spun,

their predecessors in every generation did this or that work, but, in this generation, whatever strength or help can be gained from a population of industrious cottagers, is practically lost to the country, and why? because the machines have so increased the artificial value of time, that it is too valuable to use in unproductive arts, *i.e.*, unproductive of money. The economy of labour is forgotten, the wasted energy is not taken into account, and the education of our last generation, at all events, was that of know all, but do nothing. It is possible that a sense of the dignity of labour is now being awakened within us, but the loss of that sense has sent us back many generations in the path of industrial handicraft.

It is probably the weariness of doing nothing, and a reaction in our school system in favour of hand-work, which has brought us so far on the road towards the revival of what was once England's most noted industry, that the possibility of its revival is even mooted. Four or five years ago, such a possibility was regarded as the wildest chimera, and Langdale and Windermere fought the battle alone. Winter-slow, Ramsbury, Haslemere, not to speak of Sandringham, have followed suit, and the Scotch and Irish hand industries are strong and recognised bodies, and gallant little Wales has rallied to the textile battle. Monmouth, Bristol, and Canterbury, Compton Greenfield, Satchville Heaton, and Little Gaddesden, have all their special interests, and scattered individual efforts all over the country testify to awakened interest.

The question is, if the revival spreads, how far may it be expected to extend? what are its limits? and what its possibilities? It is, perhaps, easier to speak of the actual revival and rapidly-increasing activity in the silk trade—a revival not the less to be acknowledged, though both Bethnal-green and Spital-fields have been denuded of looms and workers. On the contrary, it is rather a virtue than a failing, that the recrudescence of the silk trade, in the hand branches, has drawn its workers away from the congested city streets into the purer air and cheaper regions of Suffolk and Essex. Ipswich, Braintree, Sudbury, and the villages around—Haveril, Glemsford, and others—are becoming centres of renewed activity, and if you want hand-weavers you will find it pretty well impossible to get them.

One of the causes of this partial recovery of hand-weaving is no doubt the wave of machine activity which is sweeping over Europe. Hither-

to much of the hand-weaving in silk has been done in the mountains of Italy, in Switzerland, and the South of France. But what happened in the middle of this century in England has now taken place abroad. Capital has accumulated, and turned itself into machinery; peace has brought assurance to the capitalist, and quantity rather than quality is the goal at which he aims.

Given the possibility of obtaining good weavers in the silk trade, the proceeds of a hand factory are quite as great as those of a steam factory. The outlay in machinery in the latter instance is far greater than in the former. The time and labour of getting the machinery under weigh is for short lengths far more in a power-loom than in a hand-loom, and the work of intricate patterns is infinitely superior when placed in the hands of a practised weaver than when entrusted to automatic machinery. Hand-loom firms rarely fail—power-loom firms are not nearly, I am told, so fortunate in this respect. But the great deficiency is workers, for after the first conquest of machinery, the product of hand-labour was discounted, and the exaggerated importance and value of time seemed to paralyse industry.

The superiority of work in the hand-loom will be a matter of positive proof, and can be and is gradually becoming a subject of interest. The better the class of hand worker we train, the greater will be this difference, and the more potent will be the industrial revival which reconquers what was supposed to be an abrogated kingdom.

Here is work which, if taken up as a profession and not as a pastime, may give work to thousands of our idle and discontented country women. Here, if peace is continued to us we may find a field of conquest which may enable us to disregard the diminution of machine labour, and the loss in the quantity produced, for the demand for a better class of article is on the increase, due as we have said partly to the rapid extension of machinery on the Continent, and partly to a revival of an artistic taste for that which is in itself the work of human rather than automatic skill.

There is, however, another extensive branch of this subject which deals with questions which may, perhaps, trend on debatable ground, and therefore, I should not like to urge it, though I may state it for what it is worth. A cry has been raised against prison labour, against industry in any form which, being State-aided, might interfere with trade. But since trade in our spinning and weaving centres refuses to be

frightened by this mouse which nibbles only at chains of idleness, it is possible that there is no chance of opposition to the scheme. But the vast loss to our nation of many thousands of feeble-minded, feeble-bodied persons, who are dependent on the State or public for maintenance; of children in industrial homes, in State-aided asylums, not to speak of prisons, work-houses, and the whole mass of unorganised and unutilised energy—why should it not be turned to account, made useful to itself and to the country. Why should not the beneficent effect of manual education be extended to those who most need it, whose feeble mental capacity requires the development which such education gives.

Experiments are being made at this moment in a lunatic asylum, in a deaf and dumb home, in an inebriate establishment, and in a work-house. Why should not such experiments be extended? Why should the extraordinary intelligence displayed by deaf mutes not be turned to account? Machine labour may never be ousted from the field by hand labour, but in the competition with foreign countries who have stolen a march upon us by education and technical instruction, let us in a life or death struggle use every instrument we possess, and strain every energy in defence of our industry and commerce. Hand-weapons are good and effective at close quarters, and we may wrest from them more than one field of enterprise, and win it for our own countrywomen and our own profit.

The districts in which hand-weaving in wool flourishes are notably the outlying districts of Ireland and Scotland, where the principal sources of profit are the various tweeds, which have won for themselves a well-deserved fame.

Certainly, in one district of Ireland, the industry is so managed that not a penny of expense is incurred beyond that of absolute manufacture and cost of carriage. Advertisement is not required, for the goods advertise themselves, and are in great demand. Agents are not required, nor is any profit required beyond that which covers the absolute expenses of the undertaking. Now, of course, this fact would be sufficient to stamp the enterprise as a non-commercial undertaking, and to brand it as charity in disguise. It may, however, more justly be classed under the head of economic and industrial work, for wherever an industry puts a pound a week into a cottager's family pocket which would otherwise be dependent for subsistence on the produce of bog or moorland, such an income at once places them outside of

dependence on the poor-rates, and thus incidentally assists others as well as themselves, and adds to the prosperity of the community at large. Care, however, has to be taken in all such cases that, when once the original organisers of the work give it over into other hands, the status of the workers does not degenerate by means of certain agencies, which in another part of Ireland has impoverished a formerly most flourishing industry.

The system as it now works is this. An agent buys in London a large consignment of tea; this when delivered in the district of which I speak, costs 1s. 3d. a lb.; with each pound of tea he provides sugar to the value of about 3d. He charges that tea and sugar to the people at 3s., and gives them $\frac{1}{2}$ lb. of tea, say, for a yard of material, though the rate of payment may, in some instances, be higher. The agent sells that material in the English market for 2s. 6d. or 3s. a yard, which is not only cent. per cent. profit, but is also considerably below the actual cost of production, and thus while defrauding the actual producers, pulls down the price of labour throughout the country.

As to the cost of production. The average price, say, of wool, is from 10d. to 1s. per lb. Counting for waste, which in some wools is considerable, a pound of wool goes to a yard of material. The price of washing, carding, spinning, and oil—which Irish and Scotch industries use—comes to another 1s. The cost of dyeing is from 6d. to 9d. per lb., and the cost of weaving, from 3d. to 6d., thus bringing the cost of production, minus carriage, to 2s. 9d. or 3s. 3d. a yard. When this is sold through orthodox channels in the English market, it realises from 3s. 9d. to 4s. 6d. a yard, tailors and wholesale houses purchasing it at about the lower sum.

Now, it seems at first sight very easy to decry this system of payment in kind, but not long ago I heard that the Irish women folk preferred a system which secured to them a certain amount of grocery to the more easy payment in coin, which had a habit of going into their husbands' pockets and turning into drink. I have never been to Ireland and so cannot tell how things are managed there, but I know in an English village if a woman wants drink she can get it in exchange for bread, and I suppose there may be similar facilities in Ireland.

These details, however, explain the matter now in dispute between the two sections of the Scotch industries, one upholding the establish-

ment of grocery stores, the others avoiding any such system, which however admirably managed in the present, and the very greatest boon to outlying districts, may so easily degenerate into payment in kind, and that terrible truck system, which however illegal, may nevertheless crop up in new forms in distant and poverty-ridden parts.

With regard to other branches of hand-weaving, the one I should most urge to the front is linen. In Ireland and Scotland the tweed industry is so well established, that I would not encourage any English countries to develop that special line of weaving. It is already well represented at Winterslow and Ramsbury.

True, wool is the natural produce of this country, but if anything further is to be done in this line in hand-weaving, it ought to be in lighter fabrics, or in the old-fashioned whinsey, which lends itself to more general use than the heavy cloths, finer spun, so fashionable.

Linen, it appears is always in request, and the American market, last year, made greater demands than could be met.

In the direction of art weaving and tapestry, there lies a practically unoccupied field of delightful work. It is probably better suited for those whose natural talent lies towards the higher branches of artistic development. There are always, in every age, wealthy patrons, those who will gladly acquire rare works of art, and, though the field is limited, there is no reason why it should be deserted. It is one of the lessons we have to learn. We have all been working for time, and against time. Why not work for eternity, or, at all events, for posterity? Those who work for to-day, perish with to-day; but they who live with the knowledge that to-morrow is but the continuation of to-day's duties, that time is but an artificial division, and really is synonymous with eternity, they live really and work honestly, and throw the shuttle to some purpose, weaving a web which another may perhaps inherit, and beginning what another may complete. But while thus sketching out hastily and cursorily the possibilities which may be before us in the revival of hand-weaving, I would throw out a few hints as to the direction our efforts for its advancement might take.

The school system of to-day offers many opportunities for the training, not, of course, specialists in every branch of trade, for the object of education is not apprenticeship, but the development of general intelligence. As

with machinery, so with intelligence; directly you specialise you circumscribe your powers; directly you concentrate you may gain strength, but you lose in other directions. Nevertheless, if you wish to encourage handicrafts, the varied occupations of the Education Code gives the opportunity of educating and developing many of these faculties, and much of that manual skill which will hereafter be of use to the textile worker. Nay, more, the nature object-lessons will give the children of this generation a far greater insight into the resources of their country than was enjoyed by their forerunners, and should these fortunate circumstances be enhanced by an adaptation to older classes of similar forms of instruction, we may gain a class of worker ready prepared for hand-work, intelligent in mind, and comprehending the value and beauty of manual labour. If again the spirit of travel, which the fashionable bicycle has awakened, leads our intelligent classes to travel abroad, they may well do so with a purpose. How is it that wherever you go—in the wilds of Lapland, in the forests of Finland, on the steppes of Russia, the German traveller, inured in his early school days to foot wanderings of many weeks duration, or to the artisan tours so frequent, and so extended, is to be found omnipresent, and omnivorous (if we may use the term) in his trade hunger. Everywhere his hideous packs are to be seen, his polyglot tongue to be heard. Rather than not drive a bargain he will blunder through every continental tongue, sell his goods below the cost of production rather than not sell them at all, and all along and at every moment glean money for himself, and information for his fatherland. He will penetrate his way to the ice sea and look what the White Czar is putting up shanties for on the only open harbour of that frozen coast. He will drop down the Danube in a cattle boat, search for old coins on the Volga or the Don, and do a thriving trade all the while, till a tariff war still more severe than the last drives him back to his own country. Where all the time is the English traveller? You never meet him. You may scour these countries and tramp over Belgium. If you want a special article from abroad, and cannot get it yourself, it is not an English traveller but a German you must ask for it. Now why should these things be? Cannot we, the greatest nomads in the world, make headway against this clever and ever-dominant and intrusive race?

Surely the ambition of every English man

and woman, should be to protect our trade, our manufactures, and our commercial interest in general against this insidious policy. That patriotism is yet alive, and to be kindled by a spark, German travellers know well, and the impetus given to one home trade only, that of narrow braid and trimming weaving, by the German Emperor's telegram to Kruger was an object-lesson which might well be repeated. It is not that we cannot work, that we cannot weave, but merely that the spirit of industry has received blow after blow and has become inert. Machinery on industry, as we have said, has a paralysing effect; foreign labour invasion is almost equally numbing; while certain commercial treaties put, at least in the silk trade, a final weight to the balance, and seem altogether to lay the former energy and industry of hand-weaving trades in the dust.

If the revival of our hand-weaving is to be a success, if we are to reconquer lost ground, we must not sit still and admire our energy and be proud of our revival; we must carry our goods to the open market; we must do as the Germans do—carry our campaign into the heart of distant countries, and conquer by force of persistency as well as by the virtue of excellence. If I had time and money, I would organise a very army of lady travellers, and trust to their wit and their energy to assist the home market.

But then money must also be laid out at home. We must not only teach those who can afford to pay for instruction, but we must have the means wherewith to pay the many who are incapable of outlay. One large silk firm is already raising the roof of its establishment, in order to accommodate a large number of such hand-working apprentices. Another applied, though for what exact purpose I have not discovered, for 500 similar workers. Another, and I believe a linen firm, was reported to need 2,000 workers. And it is not always actual weavers that are wanted—winders, harnessers, enterers, twistors, harness-makers (though harness is now chiefly made by machinery), can all earn fair wages at their trade, especially in the smaller firms where gas-engines have been discontinued for winding since the Factory and Workshop Acts have been in force.

The ever-changing details of legislation affects our various trades, now in one way, now in another. Boys and girls cannot easily now obtain labour certificates before they are fifteen, but they can leave school at a much earlier age. Hence in Bethnal-green several children have, since a recent change in the

Educational Code, been taught the rudiments at all events of these arts, who would have otherwise have gone straight from school to quite a different profession.

There is no doubt the one species of legislation all hand-weavers would love to see come through Parliament. Why if we are not allowed to call margarine butter should any rubbish made of wood be called silk, or silk be so weighted with lead as to be practically a metal? Why should flax, rhea grass, cotton wool, or any other substance be allowed to pass as silk? Why should best serges be composed of rhea grass, and yet pass as serge, or velvet be made of the ravellings of waste, and be called velvet instead of schappes? We may all believe in free trade as devoutly as we believe, say, in the Divine right of kings, but free trade does not consist in deception or imitation. Machinery may not care what rubbish passes through its manipulation, but a hand-weaver must be and always is more or less of an artist. He may be, and he almost always is, an inventive genius (hence the origin of one of his mechanical substitutes for his own diligence), but he would consider it below his art, a degradation, if you will, of his genius, to make rubbish and spoil his work with bad material. Hence, hand-weaving represents not only skill, but honest work—it is the conscience of weaving a forcible contrast to the shoddy and scamping work of a machine.

We have, however, barely touched on that all-important point—wages. What can a hand-weaver earn? As a matter of fact a hand-weaver is paid better than the watcher of machine labour. He is also better paid now than at the end of the last century.

The system of payment in the silk trade has been on the system of a retaining fee. Men who were skilled in their work were, and still are in certain firms, paid from 35s. upward to £2 10s., and even £3 a week. This they had to work off during the week, but if the master had not sufficient work for them, they ran into debt as it were, a debt of work. I have known men in bad times be £20, £30, £60, and even £80 in debt to their masters. Naturally this was a heavy drain on a firm, and though in good weeks a man might possibly make from £5 to £7, as often as not the debt was never cleared off, and this system of payment is to my mind one of the chief causes which led to the employment of machine *versus* hand-weaving in silk. It is a ruinous system for masters when trade is bad.

The payment is regulated by a well-known

tariff, so many pence per yard for so many threads; an extra $\frac{1}{4}$ d. or 1d. would be added for an extra 1,000 threads, or for an additional shuttle, for the use of a Jacquard machine, or for an extra roll; so that what might at first sight seem a ridiculously low price, would mount up to more than double the apparent sum.

For women hand-weavers no such extravagant earnings are possible, because they ought only to go in for light work and narrow widths, and have to be content with from 12s. 6d. to 35s. a week. The latter is an outside price; 7s. 6d. and 10s. 6d. are the prices earned in the country by beginners. Hence it is that employers prefer country factories and women, for in both cases lower prices prevail. A guinea per week is, however, said to be a fair sum in London. A lady who can spend a small sum on silk, and has her own *clientèle*, can earn proportionately more. The payment for a silk square of a given size, is paid for at the rate of 1s. 1d. for weaving. A woman is expected to weave three a day, but it is an expectation I have never seen realised. However, that silk square contains (let us say) about 4s. 4d. of silk. If a weaver spoils it, she is charged 7s. 6d. If it is sold to the trade at 10s.; and to the general public at 12s. 6d. or 15s., then the lady would realise a handsome profit, even counting the cost of setting up her work, which is an expensive item. If she works to private orders, she can, of course, quote her own price, but even if she sold them to the trade, she would not lose by the transaction.

The paper was illustrated by a series of exhibits of silks and other materials made in the hand-loom; a hand-loom and spinning-wheel were also shown in action.

DISCUSSION.

The CHAIRMAN said the wisdom of the Society in inviting Miss Clive-Bayley to give this paper had been more than justified. In the course of the Society's history of 150 years, few papers had been given by ladies, but in each case the paper had been above the average. Some years ago Mrs. Newman lectured on jewellery, and, in 1887, Mrs. Ernest Hart lectured on cottage industries in Ireland, a subject much akin to the present, and, looking to the results, he was proud to think that he was one of the first to insist on the barrier being broken down which limited the lecturers to men. This paper had not been so much an account of hand-loom weaving in England, as an exposition of the economic side of the

subject, of which he had no knowledge. However, it had been so lucid that he had easily apprehended it, and had derived considerable instruction, while everyone would admit that, in her treatment of the subject, Miss Bayley had shown great imaginative power. It was very interesting to hear how far the revival had extended, and he thought it was a field in which female labour was most correctly applied. It was strange to find in the history of weaving, both in ancient and modern times, how different countries had differed with regard to the nature of the labour applied to it. In all Greek illustrations of hand-loom weaving found on pottery and elsewhere, and in all reference to it in Greek and Latin writers, it is always found in the hands of females; in India he never saw a woman weaving, the whole work being done by males, whilst on Egyptian monuments both men and women were depicted as weaving. What was the reason of this he knew not, but there was sure to be some interesting explanation, if anyone would follow it out. The work had been so far extended throughout Great Britain and Ireland that it really seemed worth considering whether the time had not arrived to have an exhibition in London of these local industries. It was evident that the work was strongly supported by the County Councils, and also by the gentry and aristocracy throughout the country, and from his experience of the way in which exhibitions were got up, he thought there would be little difficulty in obtaining support for such an exhibition, which would prove very attractive and do great good in the way of advertising. He did not quite sympathise with the idea of lady travellers, because it was quite bad enough to deal with sentiment as between man and man, and if ladies were introduced into relationships of that kind, he feared a great deal of distraction would result, and possibly some demoralisation in the commercial sense. Women were so enthusiastic that when once they took up a thing, their advocacy knew no bounds. He feared, therefore, that the introduction of lady travellers would only hasten our progress in an undesirable direction. The proposal for practical School Board teaching seemed a very sound one, and he was glad to know that more and more attention was being given to it. Some time ago, when at Brighton, he was talking to a fisherman on the beach, who told him that fishing would soon die out altogether, for the boys were all being taught their A B C, and they became quite unfit for fishing or any hard work. He said there were plenty of them along the terraces above, looking down on their fathers, and thinking what fools they were to work so hard. It was high time to alter that kind of thing, and give the children of the industrial classes a more practical education. He begged leave to propose a hearty vote of thanks to Miss Clive-Bayley.

The vote of thanks having been carried,

Miss CLIVE-BAYLEY said she thought lady com-

mercial travellers would have a great deal to learn from the men as to the way of pushing their wares. She was talking to an Irishman the other day, who showed her specimens of what he called hand-loom work, but, on being pressed, said first they were as much hand-made as possible, and finally admitted that they were not hand-made at all. In another case a traveller brought her some things which he wanted her to exhibit for sale, which he said were hand-made by English ladies, but had to admit that they were made in France, by machine, and were not pure silk, as they were represented, but only of what passed in the trade as pure silk. She did not think any lady would have gone as far as that.

Mr. J. W. LOVIBOND said he should like to thank Miss Bayley for her paper, and also to ask her if she could give any suggestions with regard to the starting of these industries in villages, especially in the way of finding a market for the goods. He referred more especially to woollen goods, not the fancy goods which were principally shown that evening. One of the conditions of starting such an industry, he understood, was that the work-people were paid so much per lb. for all the wool they spun, and that involved someone finding capital to start with, and, of course, it was very important to get substantial returns as soon as possible. There was an interesting experiment going on, as an offshoot from the Winterslow industry, to see if the villagers could be got to clothe themselves and the farmers in their district, the basis being that instead of the whole of the funds to pay for the spinning being provided, only half was to be paid in cash, the other half being taken out in clothing. If this were successful it would lessen the difficulty of finding a market, and would help to find employment for the women and girls. He had watched the Winterslow industry from its commencement, and knew how much labour, energy, self-denial, and application had been thrown into it to make it the success which it was. Formerly it was one of the hardest villages in Wiltshire, and he knew personally how much the condition of things had been ameliorated, and what comfort had been brought into many a cottage.

Mr. THOMAS BOLTON asked if Miss Bayley could give any idea of the cost of establishing one of these industries; for example the cost of the machine, the probable cost of tuition, and the outlay necessary for material to make a start. There was no doubt that people in villages did waste their time terribly in frivolous ways, but if anything in the nature of remunerative employment were offered them many of them would be disposed to embrace the opportunity. One of the most deplorable things in agricultural England was the way in which the small industries had gone out of existence. Even twenty years ago, in a district with which he was pretty well acquainted, he could not let a cottage unless it had a good brick oven in which the bread could be baked. Now such a thing

was not wanted. Bakers travelled the country selling an inferior and much less nutritious article, and the brick oven had ceased to exist. Again, there used to be rope walks, where good useful ropes were made for the wants of the neighbourhood, now nothing of the kind existed, and many similar illustrations might be given. The question of the market was a difficult one, but he believed that if a good article were produced sooner or later it would find a market. The great complaint now was of shoddy articles, and mixed articles, not up to sample. The tendency was, when a man had established a trade, to reduce the quality in order to make more profit. Hand work could never hope to compete with the great machine industries of the country, but all events a good deal of employment might be provided for cottagers, and that, of itself, would be an immense advantage.

Mr. BARRY thought there would be very great difficulties in doing much of a home trade, owing to there being so much competition, but suggested that with the help of the Imperial Institute a good trade might be opened up with the colonies. It might be imagined that in that case the exporters would have a long time to wait for their money, but that was not so, because when orders or indents were sent from the colonies, the shipping houses in the city would make advances on the goods as soon as shipped, to the extent of something like 90 per cent. of the invoice price.

Mr. S. S. BROMHEAD said it appeared to him that this was a gigantic undertaking, which it would be very difficult for private enterprise to grapple with. Capital was required to provide the looms and wheels, purchase material, and pay wages, and he would suggest that it might be dealt with by the agency of the Poor-law, if necessary, additional power being given by Parliament. Boys in workhouses were now taught shoemaking and carpentering, and girls laundry work, and so on, and he thought the Guardians might extend their operations, and advance capital to the rate-payers for the purpose of establishing cottage industries; whilst by the machinery of the department they would be in a position to know where the product could be disposed of. Mr. Barry had drawn rather a fancy picture of the facility with which goods could be exported to the colonies, and large advances obtained upon them. From what he knew of that kind of business, he should say that considerable expense had first to be gone to in sending out samples, sometimes without any result, and, at any rate, it would be six months before orders would be received. Exporters to the colonies were constantly being undersold, and in this case they would have to meet the competition of both English and foreign machine-made goods at lower prices.

Miss CLIVE-BAYLEY, in reply, said she had already mentioned in connection with the Winterslow industry that she did not wish to urge any further manu-

facture of similar woollen goods at present, lest the market should be overstocked. But she had noticed in passing the stores of the Scottish Industries that bales were continually going to America, Africa, and Hong Kong, and on inquiry she was informed that a large colonial trade was being developed, but she had no figures to show the extent which it had reached. There was no doubt that these hand-made goods were largely used. Last year, if she had had hands enough to carry out the work, she could have had a large business in a cloth, such as was used in South Africa. She could have disposed of thousands of yards, but, not having hands, she lost the opportunity, and then the difficulty was to find a market. That was partly why she suggested lady travellers, because whenever you had a new industry, you wanted a market. In starting a new branch, she generally made it a point that something should be taken up different from what was produced in other villages, so that there might not be a glut of one kind of work. At the present moment she had orders for aluminium cloth quite beyond her power to carry out, because no one else had the aluminium thread which she had, and which was much admired. She was also told that there would be no difficulty in finding a market for certain small braids, which were at present only made in Paris, which were very fashionable for ladies' dresses. She had two ladies who did nothing but braid work. Some people gave away their work at first in order to advertise it, and generally ended by making a good market. Any new industry in the way of workers ought to be in the finer qualities. She had been asked to supply vicuna cloth, but had not done so, not having the necessary capital to get the material. To a private individual the question of capital was the great difficulty, and one had to go cautiously. The most practical way she could suggest for finding a market, was to take a shop or a window in Bond-street, but seeing that the rent of a ground floor was about £700 a year, that meant a large capital. Still, she had no doubt it would pay. The expense of starting an industry depended on how it was done. The cost of a small loom was £3 10s., and a wheel 25s. The material she bought wholesale, and sold as nearly wholesale as possible, simply to cover expense. Quite recently she lost a good offer from a shipping agent, who wanted her to make tabarets, such as were made in North Italy, because she had not hands enough to carry it out; this would have found work for forty ladies if she could have got them. £40 or £50 ought to cover the cost of starting a village industry, teaching thirty or forty persons, apart from the question of rent. The other day she was asked to take up an Irish industry, which had fallen through owing to the truck system, and was told that £400 or £500 would make a very thriving industry of it. For a silk factory some £2,000 would be wanted, but with good business management it ought to pay well. Some of the earlier experiments cost more than they would

now, because, for one thing, she had gained knowledge and experience, and was able to purchase materials much cheaper than before.

Miscellaneous.

DAIRY FARMS IN THE NORTH OF FRANCE.

Dairy farming in the North of France—one of the chief agricultural industries—is still in its infancy when compared with the same industry in other countries of Europe. Some large dairy farms on the modern system are now being started at Roubaix. The usual system in vogue is as follows:—A dairyman arranges with several small farmers to take all of his milk at stated times and at fixed prices. These farmers have cooling rooms where the milk is put in shallow pans, and the cream allowed to set. The churning is done in a wooden churn shaped like a low washtub. The butter is put on stone slabs to set. The milk left from churning is sold to milkmen, who derive a good profit from its sale, as the inhabitants of the north boil this milk with rice and chopped apples, and use the mixture as an article of food; it is considered healthful. In the winter the milk from churning is often given to the cattle. In summer the cattle feed on grass, clover, hay, and green Indian corn; in winter they are fed on beet-roots and tops, potatoes, refuse of sugar mills and distilleries, and a large quantity of cotton seed and linseed cake; the windmill oil cake being the most in demand on account of its large percentage of oil. The United States commercial agent at Roubaix says that the linseed cake made in France for feeding purposes must contain 9 per cent. of oleaginous matter, and from 20 to 25 per cent. of albuminous matter. As a rule cow-houses are lofty, well-aired, and clean, and are always whitewashed and tarred. They are usually of brick and stone and with thatched roof. The average price of milk is two pence per litre, the litre being equivalent to 1·76 imperial pint; the quality, however, is not rich on account of the meagre pasturage. Butter is sold at about 1s. 5d. a pound, and is sold to the retail trade in parts of one-half pound, one pound, and two pounds. Farmers usually send their butter to market in blocks of 40, 60, and sometimes 80 pounds, selling whatever quantity may be demanded. Pure butter is rare, as oleomargarine is largely used. In one department there is a factory which carries on business on so large a scale that it has its own railway trucks to deliver the margarine in all the principal towns in France. It is stated that margarine is manufactured in Paris at the rate of 33,000 pounds a day. The margarine is distributed between Holland, England, Normandy, and Brittany. In the last two localities it is mixed with the butter of the country. The highest class butter in France is made in Isigny, Bayeux, and Gournay.

Correspondence.

ANCIENT AND MODERN INK.

The word ink is derived through the Old French *énque*, and Latin “*encaustum*” [“*encaustum*” became the Italian *inchostro*], from the Greek *énkausto* “burnt in,” “painted in encaustic”; and it refers to the practice of the earlier Greek artists of applying their colours with wax, in order that when heated the might be more deeply absorbed by the surface on which they were spread; and long after the Greek and Roman artists learned to paint with fluid [watery, gummy, mucilaginous, &c.] colours, the latter were still called “*encausta*,” as in the case of the “*encaustum sacrum*,” or red ink used for the signature of the Byzantine Cæsars; the use of which by others was punished by death [cf: “the Vermillion pencil” of the Emperors of China].

The *thing* ink—the fluid vehicle, of varying composition and colour, of writing, as the art is practised by us—was originally the “black” substance known to the Greeks by the names of *mélán* and *melanteria*—*melanodocheion* being their name for “inkstand,” and known to the Romans by the name of “*atramentum*,”—“*atramentarium*” being their name for inkstand. But just as the name of the waxy *encausta* passed on, in the forms of *énque*, and “ink,” and *encre*, &c., to the fluid vehicles of writing, so the name of “*atramentum*,” or the “black-(?)menstruum,” came in Rome to be gradually given to any “*atramental*,” i.e., “ink-like” fluid, such as “*liquor ruber*” and “*liquor viridis*,” fit for writing,—“*scribendo aptus*,” and similarly in modern Greece *mélán* and *melanteria* may be any ink of the brilliant aniline series, as well as the best black.

Pliny, Book ix., chap. 45 (29), says that the cuttlefish [“*sepia*”], when chased, discharges “*atramentum*,” the black natural fluid, long erroneously supposed to be the source of “Indian [i.e., Chinese, Ink.” In Book xxxii., chap. 52 (10), he says that “*atramentum sepie*” is of such blackness that if burnt in a lamp the persons present look black! In Book xxxv., chap. 25(6), he again says that the *sepia* has a wonderful property of secreting “*atramentum*,” but adds that from this no colour is prepared. It is in this place that he enumerates the seven kinds of atrament known to him, in addition to “*atramentum sutorium*,” or shoe-black, to be noted later on, viz.: (1) “bone black,” apparently infected with sulphate of copper; (2) “lamp black,” or “smoke black,” obtained from the burning of pitch or resin, or best of all, of the torch pine [“*taeda*,” *Pinus Mugho*]; (3) calcined vine lees, i.e., “charcoal,” used by Polygnotus and Micon under the name of *trigynon*; (4) “ivory black,” invented by Apelles under the name of *elephantinon*; (5) “Indicum,” here, apparently, not “indigo,” but “Indian Ink”; (6) an atramentum from the inflorescence which forms on brazen dust-pans, i.e., “smoke black,” with pos-

sibly an admixture of sulphate of copper; and (7) sepia. Pliny adds that every kind of atrament is completed by exposure to the sun; that for writing, "atramentum librarium," "having an admixture of gum," and that for plastering, "atramentum tectorium," "an admixture of glue." In Book xxiv., chap. 1, he says that "atramentum," and he here evidently means "a: librarium," is most easily removed with water; a passage which tends to prove that the ordinary "ink" of the Romans contained neither salts of iron, nor galls, nor other mordant, but was simply an admixture of "bone black," or "ivory black," with some watery or gummy or mucilaginous fluid.

Identically, the ink of Dioscorides, *Peri Melanos*, is composed of three parts of "lamp black" and one part of gum, dissolved in water. This was probably the earliest known receipt for black "ink;" and it possibly goes back to the most ancient times. Its discovery is attributed to the Chinese, but the Egyptians also knew it, and before them, and may have transmitted it to them through the Chaldeans. In "the Book of the Prophet Jeremiah," xxxv. 18, Baruch is described as writing down Jeremiah's prophecy against Israel "with ink in the book." In "the Book of the Prophet Ezekiel," ix. 2, one of the men seen "in vision" by the prophet is described as "clothed in linen with a writer's inkhorn by his side," i.e., hanging from, or stuck in, his girdle, just as the inkhorn is carried in India, and throughout the East, the morning lands of light and civilisation, to this day. Then, from the "Book of Numbers" we find that the ink of the ancient Hebrews was soluble in water, for it is there (v. 23) stated that a woman, under ordeal for suspected infidelity, was made to gulp down certain curses, by first writing them down in a book, and then dissolving them out with water, mixed with dust from the floor of the tabernacle, and giving her to drink of this "bitter draught" of "the water of jealousy."

Again, throughout India the best ink, used for writing on palm leaves and on paper, is made of equal parts of lamp black and gum arabic, dissolved in the juice of the aloe leaf and dried in the sun. After it is dried, a portion is dissolved in water as wanted. "Indian Ink," that is, Chinese stick ink, similarly made, like the best Roman "atramentum," is from the "smoke black" of burning pine branches. It is scented with musk, and, as described in the *Builder*, and stamped with the "dragon pattern," which is silvered or gilded.

But it is evident that the ancients, or at least the Romans, also knew of a mordant atramentum. Pliny, in Book xxxv., ch. 25 (6), already quoted, distinctly says, atramentum dissolved in vinegar is not easily washed out with water:—"Quod autem aceto liquefactum est, ægre eluitur." Again, Book xiv. ch. 26 (11), the test he gives for detecting sulphate of iron in sulphate of copper, proves that he knew a mordant atramentum that could be used for writing-ink, and on paper:—"The fraud may also be

detected by using a leaf of paper ["papyrus"] that has been steeped in an infusion of nut-galls, for it becomes black immediately on the genuine verdigris being applied":—"Nigrescit enim statim æruginè illita." In this context should also be read the account given in the same Book, chapter 28 (12), of the preparation of "shoe black," "atramentum sutorium."

The etymology of the word palimpsest, meaning a manuscript which has been twice written on, that is a second time over the first writing, or after the first has been removed. The word is made up of *pálin*, "again," and *psistós*, "scraped," and refers, originally, to parchments, *Charta Pergameæ*, the first writing on which had been more or less scraped off to make way for a second writing thereon. A soluble ink would have been washed off, and the operation of "scraping" implies the use of an indelible, or mordant ink. In fact, you cannot write on parchment comfortably, except with a "biting" ink. It is highly probable, indeed, that mordant inks came into use with the invention of parchment, in the second century before Christ.

The mediæval prescription for mordant ink, given by Theophilus, Book i., chap. 40, "De Incausto," is in summary, this:—"Cut with your own hand twigs from the hawthorn trees in April or May, before they put forth their leaves and flowers, and lay them by in the shade to dry somewhat. Then pound off all the bark and put the same into casks full of water, and let them stand for eight days, until the water absorb all the sap of the bark. Then pour out the water into a pan or a cauldron, and boil it; and then throw in more bark, until you boil all the sap out of it, and repeat this until the water is boiled down to a third; and then boil this until it grows black, and begins to thicken, taking care to add no more water. Then add one-third of pure wine, and put it into three new pans, until a skin forms on the surface. Then place the pots in the sun, until the black ink separates itself from the red dregs. Afterwards, pour the pure ink into small bags of parchment, or bladders, and hang in the sun until all is quite dry. And when dry, take as much as you want, and mix with wine over a fire, and add a little 'atramentum' [here sulphate of iron], and write."

The above detailed quotations, illustrative of the ancient history of writing-ink, will, I hope, be found to add to the practical value for future reference of the interesting and suggestive article in the *Builder*.

GEORGE BIRDWOOD.

General Notes.

THE WORLD'S COAL PRODUCTION.—An interesting statement has recently been prepared by the French Ministry of Public Works showing the

quantities of coal produced in the principal countries of the world. The following particulars, which are inclusive of lignite, have been taken from the statement in question, and refer in each case to the year 1896, unless otherwise stated:—United Kingdom, 198,487,000 tons; United States, 168,957,000; Germany, 112,438,000; France, 29,190,000; French Colonial Possessions, 137,000; Austria, 28,112,000; Belgium, 21,252,000; Hungary (year 1895), 4,586,000; Russia (1895), 9,009,000; Australasia, 5,745,000; British Possessions in Asia (year 1895), 4,442,000; Japan (1893), 3,329,000; Central and South America (1895), 992,000; Spain, 1,923,000; Portugal (1892), 18,000; Italy (1895), 305,000; Sweden, 226,000, and Greece, 14,300 tons.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock:—

MAY 11.—“Water Gas and its Applications.” By Prof. VIVIAN B. LEWES. CORBET WOODALL, M.Inst.C.E., in the chair.

MAY 18.—“The Evolution of the Cycle.” By J. K. STARLEY. C. V. BOYS, F.R.S., will preside.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock:—

MAY 19.—“Chartered Companies and Colonisation.” By Sir ALFRED COMYNS LYALL, G.C.I.E., K.C.B., D.C.L. (Member of the Council of India). HENRY M. STANLEY, M.P., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday afternoon, at 4.30 o'clock:—

MAY 24.—“The Goldfields of British Columbia.” By W. HAMILTON MERRITT. Sir CHARLES MALCOLM KENNEDY, K.C.M.G., C.B., will preside.

APPLIED ART SECTION.

Tuesday afternoon at 4.30 o'clock:—

MAY 10.—“The Life-Work of William Morris.” By F. S. ELLIS.

CANTOR LECTURES.

Monday Evenings, at Eight o'clock:—

PROF. CHARLES A. CARUS WILSON, M.A., M.Inst.E.E., Professor of Electrical Engineering, McGill University, Montreal. “Electric Traction.” Four Lectures.

LECTURE II.—MAY 9.

Acceleration—Conditions under which a train is started—Method of drawing acceleration curves—Uniform and variable acceleration—Example—The City and South London Railway—Control—Comparison of different methods—How to ensure a smooth

start—The series-parallel controller—Example—The Liverpool Overhead Railway—Different ways of handling the controller—Example—The Buffalo and Niagara Falls Electric Railway—Effect of the slipping of the driving-wheels.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 9... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. Carus Wilson, “Electric Traction.” (Lecture II.) Royal Institution, Albemarle-street, W., 5 p.m. General Monthly Meeting. Geographical, University of London, Burlington-gardens, W., 8½ p.m. Medical, 11, Chandos-street, W., 8½ p.m. General Meeting.

TUESDAY, MAY 10... SOCIETY OF ARTS, John-street, Adelphi, W.C., 4½ p.m. (Applied Art Section.) Mr. F. S. Ellis, “The Life-Work of William Morris.”

Royal Institution, Albemarle-street, W., 3 p.m. Dr. S. R. Gardiner, “The Historical Development of Europe.” (Lecture II.)

Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.

Photographic, 5A, Pall-mall East, 8 p.m.

Anthropological, 3, Hanover-square, W., 8½ p.m.

Colonial Inst., Whitehall-rooms, Whitehall-place, S.W., 8 p.m. Major A. St. H. Gibbons, “Marotseland, and the Tribes of the Upper Zambesi.”

Asiatic, 22, Albemarle-street, W., 3 p.m. Annual Meeting.

WEDNESDAY, MAY 11... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Prof. Vivian B. Lewes, “Water Gas and its Applications.”

Royal Literary Fund, 7, Adelphi-terrace, W.C., 3 p.m.

United Service Institution, Whitehall, S.W., 3½ p.m. Rev. J. H. S. Moxley, “A New Theory of the Tides.”

Royal Society of Literature, 20, Hanover-square, W., 1 p.m.

THURSDAY, MAY 12... Royal, Burlington-house, W., 4½ p.m. Antiquaries, Burlington-house, W., 8½ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. “Lord Rayleigh, “Heat.” (Lecture I.)

Electrical Engineers (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m. 1. “Prof. J. A. Ewing, “A Magnetic Balance for Workshop Test of Permeability.” 2. Mr. A. J. Gibbings, “The Registration of Small Currents used for Electric Lighting and other purposes.”

Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, MAY 13... United Service Institution, Whitehall, S.W., 3 p.m. Capt. G. Neal, “The Evolution of Volunteer Position Artillery into Auxiliary Field Artillery.”

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting, 9 p.m. Prof. W. A. Tilden, “Recent Experiments on Certain of the Chemical Elements in Relation to Heat.”

Astronomical, Burlington-house, W., 3 p.m.

Clinical, 20, Hanover-square, W., 8½ p.m.

Physical, Chemical Society's Rooms, Burlington-house, W., 5 p.m. Prof. W. E. Ayrton and Mr. T. Mather, “Galvanometers.” (Part II.)

SATURDAY, MAY 14... Royal Institution, Albemarle-street, Sir Walter Parratt, “Programme Music.” (Lecture IV.)

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FRIDAY, MAY 13, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.**CONVERSAZIONE..**

The Society's *Conversazione* will take place at the Natural History Museum, Cromwell-road, S.W. (by permission of the Trustees of the British Museum), on Wednesday, 22nd June. The reception will commence at 9 p.m.

The following portions of the Museum will be open:—On the Ground Floor—the Central Hall, British Saloon, and Bird Gallery; on the First Floor—the East and West Corridors, and the Lecture Room.

Each member is entitled to a card for himself (which will not be transferable), and a card for a lady. In addition to this, a limited number of tickets will be sold to members of the Society, or to persons introduced by a member, at the price of 5s. each, if purchased before the date of the *Conversazione*. On that day the price will be raised to 7s. 6d.

These tickets will only be supplied to persons presenting members' vouchers (which can be obtained from the Secretary) or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, claret cup, &c.) will be supplied.

Visitors arriving or leaving by either of the Metropolitan Railways will be allowed the use of the District Company's Subway, which leads from the South Kensington Railway Station direct into the grounds of the Museum.

CANTOR LECTURES.

Prof. CHARLES A. CARUS WILSON, M.A., M.Inst.E.E., delivered the second lecture of his course on "Electric Traction," on Monday evening, 9th inst.

The lectures will be printed in the *Journal* during the summer recess

APPLIED ART SECTION.

Tuesday afternoon, May 10, 1898: Dr. RICHARD GARNETT, C.B., in the chair. The paper read was "The Life-Work of William Morris," by F. S. ELLIS.

The paper was illustrated by an exhibition of examples of Morris's skill in calligraphy and illumination, kindly lent by Lady Burne-Jones; the Kelmscott Press publications, by Mr. Emery Walker; tapestries—one of the "Four Seasons," from Morris's own design, by the Science and Art Department, the other a reproduction of Sandro Botticelli's "Primavera" from the Accademia at Florence, by Messrs. Morris and Co.; also several examples of carpet work, numerous hangings of woven stuffs in velvet, silk, and cotton, and wall-papers, lent by Messrs. Morris and Co.

The paper and report of the discussion will be published in a future number of the *Journal*.

Proceedings of the Society.**INDIAN SECTION.**

Thursday, April 28; Sir DAVID M. BARBOUR, K.C.S.I., in the chair.

The CHAIRMAN, in introducing Sir Edward Sassoon, said they were met to hear a paper on the currency of India. No words were necessary to impress on the audience the importance of the question, both as affecting India and the United Kingdom, and they were especially fortunate in having as the author of the paper, Sir E. Sassoon, whose connection with India, and whose knowledge of the conditions of production and trade in the country, and his long study of the subject, would make his opinion of great value.

The paper read was—

INDIA AND HER CURRENCY.

BY SIR EDWARD SASSOON, BART.

My first duty is to express to Sir David Barbour my grateful acknowledgments for the few considerate words with which he has introduced my name to this select audience; and, not less, for so readily acceding to our request to preside over our proceedings and deliberations. He has filled, with conspicuous ability, the highest financial post in that magnificent dependency of ours; he has since added to that reputation by various contributions on matters of financial moment, and can, therefore, sum up with an authority and influence second to none. I do not know whether, when we come to disperse, we shall have discovered the philosopher's stone, or cut the Gordian

knot, to everyone's satisfaction, but we shall perhaps have succeeded in casting the horoscope of the probable time when India's financial and economic state of suspended animation will cease. The Chairman has truly said that the subject in hand is one of capital importance, because if a country's best interests depend upon the steady progress of its trade and commerce, and this in turn is affected by the soundness of the lines upon which its system of currency is based, then India, with her comparatively backward and poverty-stricken people, may be said to hover on the brink of what may conceivably prove a formidable crisis. Her commercial and industrial relations with the United Kingdom are so vast and varied, the trade of the two countries has become so mutually indispensable to the wage earners of both nations, and a right or a mistaken ordering of her money has such a direct and all-important bearing on the uninterrupted flow and gradual expansion and development of these trading relations, that an apology seems scarcely required for intruding some considerations in regard to the recent currency efforts of her Government upon the attention of your Society. Give me good finance, exclaimed a celebrated minister, and I undertake to give you a good policy.

The Indian Government still adhere to their proposal to establish a gold standard, and they believe that in the immediate future they will be able to rely on the effective maintenance of the rate of 1s. 4d., modified only by the variations in rate due to the bullion points between the import and export of gold. But whether, after a period of probation lasting over close on five years, we are within a measurable distance of the goal as the authoritative exponents of that scheme would fain believe, or whether, as the profane sceptics allege, we are no nearer the Promised Land, and that thus the sole effect of the contraction of currency has been to bring about famine values for loanable capital, while no sort of confidence is felt in present rates of exchange, are questions which it is highly important to examine into. In entering into a speculative analysis of the chances and immediate prospects of that scheme, it will be my aim to maintain a dispassionate and almost a judicial attitude, the object being to invite discussion and to elicit views and varying phases of thought on the best and soundest steps to be adopted, in order to solve a problem of such magnitude and of no little perplexity. At any rate, if as the

result of the interchange of views, even some of the doubtful points which have foregathered round this crucial situation are elucidated, and as a consequence the matter is by so much advanced, our meeting here will not have been held in vain. I have closely followed and studied the course of the economic disturbance of prices since the severance of the link between the two metals in 1873, and I give you my conviction for what it may be worth—that a system of international bimetallism, with due safeguards, and based upon some not unreasonable ratio, with the at least partial support and benevolent countenance of this country, seems to be the only method by which the maintenance of values can be secured, and, as a consequence, freedom from harassing financial and economic unrest. Since, however, a considerable mass of banking and other authorities scout that view, and as the mention of that word, that portentous shibboleth—unlike the blessed word Mesopotamia—provokes imprecations in all the moods and tenses, and acts upon some of the monometallists rather as a red rag to a bull, I shall discard both the word and its doctrines for the purposes of this paper. There is though, a direct, not an unseverable connection between the two.

Now let me recall briefly the history of the immediate origin of the causes that led to the closing of the mints in India. You remember the abortive result of the last Conference held in Brussels in 1892. Its dispersal was regarded as a great triumph for those who consider silver unfitted for any other than the humblest functions of token coinage. The worshippers at the shrine of a single gold standard exulted, believing that their opponents' views had received their final quietus. The failure at that Conference of Mr. Alfred de Rothschild's proposals for a somewhat extended use of silver, a perfectly harmless experiment, was unfortunate, as if it had been properly carried into effect, it would have proved an excellent object-lesson as to the possibility of raising the gold value of silver. But the failure of that proposal, coupled with the provision of further hostile measures in the direction of demonetization, induced a further serious fall in silver. The Indian Government, getting naturally alarmed at the dead-set made against the metal to which they, of all other Governments, gave the unlimited hospitality of their mints—and dreading the imminence of the repeal of the Sherman Act—a measure which, if carried

out, threatened to displace no less an amount than 54,000,000 of ounces of silver per annum from the currency systems of the world—asked the India Council for authority to close their mints to private coinage. They further suggested that the suspension of coinage should be accompanied by the promulgation of a decree declaring their willingness to receive gold, and to give rupees in exchange at the rate of one rupee for every 1s. 6d. in gold. The now famous Herschell Committee was appointed, and after some hesitation and searching of hearts, they decided to recommend the adoption of the views of the Indian Government as regards mint-closing, and suggested that the rate of 1s. 4d. for the exchange of rupees into gold would prove a more workable figure.

The Secretary of State for India followed the advice of the Herschell Committee, and gave authority to the Indian Government to close the mints whenever they might think such a step advisable. To the great surprise of most persons interested, the Indian Government proceeded, without any delay whatever, to exercise the authority thus granted to them and closed the mints to silver for private coinage, though we now know that Sir David Barbour did not personally favour the policy of immediate closing. As the Indian Government had for the previous twelve years been urging on the Home Government the great importance of an international agreement among the leading nations so as to fix a par of exchange between silver and gold, it was confidently relied upon that the Indian Government would have then availed themselves of the opportunity of endeavouring to bring about such an arrangement. The power of closing the mints gave them an immense leverage in urging France, the United States, Belgium, Holland, &c., to action, as if the Indian mints were once closed the United States would practically be forced to suspend their purchases of silver, and a stupendous change would be produced in the relative use of silver and gold, thus enormously aggravating the existing monetary difficulties.

The rate of exchange ruling at the time was 1s. 2½d., and the price of silver was in the neighbourhood of 38d. the oz. At one bound this declined to close upon 30d. But the gold value of the rupee jumped up to 1s. 3½d. It, however, remained there but a very short time, and although the refusal of the India Council to sell its drafts at anything below 1s. 3¼d. tended to maintain nominally that rate, yet transactions

were extremely limited. The banks and merchants preferred to await further developments, and showed great and not unreasonable scepticism as to the ability of the Government to make the necessary sacrifice involved in the abstention from the sales of its bills. These presentiments proved only too well founded, as after a short interval the Council found it imprudent to keep up the struggle. A few lacs of rupees were tendered for at rates varying from 1s. 3½d. down to 1s. 3d., and so on, week after week the downward tendency went on with accelerated speed until, after rather wide fluctuations, the rate touched the abnormally low figures of 1s. 0¾d., about a year after the decree. An illustration of the frailty of human calculations! The members of the Herschell Committee reckoned without their host in failing to believe in the probability of a large upheaval of the hoards of silver money, which actually took place. Not only that, but from Zanzibar, from the littoral of the Red Sea, the Straits, the Malay Peninsula, came coined rupees for the purpose of being exchanged for the greatly cheapened metal of which the rupees are composed. The immediate consequences of the rupture of the link between silver and the rupee was shown in the large falling off in exports to silver-using countries, the phenomenal drop in the Mexican dollar as measured in rupees, viz., from 225 rupees bullion parity to 170 per every 100 Mexican dollars, caused by the divergence of the respective bases of the two standards, thus inflicting enormous losses on those having to make remittances from China and Japan, who had disposed of their merchandise, relying on the previously prevailing rate. These two sets of occurrences, the bringing out of the hoards on the one hand and the check to exports both to silver and to gold-using countries on the other, caused a contraction of the demand for rupees to proceed *pari passu* with the restriction of their supply. Commerce has, in well-regulated countries, a marvellous power of adjusting itself to altered circumstances, and in the case of India, we see this fact realised, but the influence of the contracted currency has, with a more active course of trade, caused such a stringency in loanable capital—rates in the open Bazaar having been quoted as high as 24 per cent—that it appears to baffle all the efforts hitherto attempted by the Indian Government to mitigate this great stumbling block to the progress of commerce and industrial enterprise.

It must be understood, however, that I am

not questioning the wisdom of the new policy as a temporary expedient in an emergency, or even remotely suggesting that the home Government should have overruled the desire strenuously expressed by that of India. It is always easier to judge after the event. As practical people, we have to look at accomplished facts in their practical aspects—to endeavour to decide for ourselves by the light of the experience of the past and the teaching of the present in forecasting the future, and to see whether the balance of argument and of public advantage points to the desirability of the scheme being revoked or being given a fresh period of grace, or of being persevered with for all human time at all costs and sacrifices of India's best interests. Besides, were I inclined to condemn the policy, I should experience the greatest difficulty in rebutting the arguments of the Indian Government, who foresaw the perils that seemed imminently likely to threaten their exchequer (although two eminent authorities—Sir Robert Giffen and Mr. Barr Robertson—dissent from the justification upon which that act was grounded), I should be in dire straits to solve the knotty problems of the “what would have been,” whether bimetallism would have been adopted, whether the Sherman Law would have received its *coup de grâce*, whether Japan would have seen fit to discard silver in pursuit of a fashionable currency policy, whether the mine-owners of Colorado and Montana would have seen the prudence of curtailing their output in accordance with the altered fortunes of silver, the increasing capacity of the natives to absorb the metal, &c. Upon exact knowledge of these and many other points would depend the pronouncement *ex cathedra* as to the correctness or otherwise of the Indian Government's forebodings in 1893. The above is a brief summary of the salient features that characterised the monetary affairs of India up to the time—the momentous time—when the Wolcott proposals were made to our Government. This was a new departure, the full and cardinal significance of which will, in due course of events, I believe, not fail to be recognised. Before, however, entering at some length into the question of these overtures, it would, perhaps, be more in consonance with the views of this audience that we should face the even still more crucial question as to whether the Governments here and in India have given more proof of faith and courage than of foresight and prudence in proclaiming *urbi et orbi* the advent of the

“eve of success” of their policy, and how far the method adopted and that likely in the immediate future to be adopted, have in them the germs of a successful result.

Now I start with the assumption that were India to be endowed out of hand, by some miraculous interposition of Providence, with an effective gold standard with silver coins linked to it at the ratio tumbled upon by the Herschell Committee, it would be a boon and a blessing to the country and to her customers. In the absence of this supernatural agency, and in order to avoid the ruinous derangement of business, the dislocation of industry in all its forms, both of which are delicate organisms requiring to be nurtured and fostered on freedom from harassing uncertainties and on an unstinted automatic currency, I take it that the following four propositions are of elemental consequence as indispensable for the fulfilment of the requisite conditions of an effective establishment and maintenance of a gold standard. I put them—with the exception of the first, which seems a self-evident proposition—in the form of interrogatories, because I totally lack confidence in my ability to answer for their reaching any practical stage.

1. There must be a certain minimum quantity of gold for a Conversion Fund.
2. Is gold likely to be attracted into India even to this small extent in the immediate future?
3. Is it not desirable to have an effective concurrent circulation of the two kinds of money?
4. Would it not be necessary to prohibit the importation of the silver metal, seeing that this uncoined metal is being used as barter in up-country districts?

With regard to the first point, Sir David Barbour calculated that an amount of £15,000,000 of gold would be adequate to begin with for the maintenance of a gold standard, and that figure appears to have been based on the view that the active rupee circulation amounted to about 115 crores.

The second point, namely, the likelihood of gold being drawn to India, is a matter of such uncertainty, its sudden realisation to this large extent would cause such a financial earthquake in every monetary centre of Europe and the world, that it is difficult to grasp its possibility, be the conditions conducive to its attraction and accumulation ever so favourable. Personally, I do not believe much gold is likely to be sent out, unless the Government decree their readiness to exchange it for all times at a fixed rate, so that they might for example give 1s 3½d. for a rupee. Should they do so, and

under this encouragement large sums are sent out, the risks attendant on the assumption of such vague, yet vast, liabilities need only to be mentioned to be recognised. They may be called on to produce millions of gold almost at a moment's notice.

The third point, as to concurrent circulation of two metals, raises a most serious issue. Here we should have to battle with the ingrained immemorial propensity of the Indian to hoard or to keep gold and silver coin in a dormant state—a habit which 100 years of settled British rule and relative prosperity have not succeeded in curing him of, or even the native princes for the matter of that. A superior officer stationed at Hyderabad was told by one of the nobles, who stands near to the *gadée*, that when demolishing certain walls a treasure trove full of gold mohurs was found, whereupon the officer promptly inquired if his Highness meant to make a judicious investment of the find. "Not if I know it," was the unhesitating rejoinder, "the gold will go back to some other equally secure resting place, because once money sniffs the air it has an uncomfortable way of walking away." In my opinion the leopard will have changed his spots, before the natives will be got to see the utter folly of hiding away endless masses of capital instead of employing it reproductively. It is, however, hardly an eventuality to be reckoned upon in the declining years of this century. Then there is another dangerous yet obscure factor to be taken into account, namely, that of illicit coinage in native States and neighbouring hill provinces, so difficult of detection. These two elements—hoarding and illicit coinage—will naturally be the disturbing quantities which must ever tend to baffle the astutest plans, and to interfere with their success. One is told that in systems of currency like, for instance, that of Italy, no such concurrent circulation exists, nor in most provincial towns there does any coin circulate at all and copper takes its place. Its exchange fluctuates also considerably in consequence, and I hardly think you would approve of any servile imitation of such systems with their serious drawbacks.

The case of France is widely different, and I venture to think Sir James Westland made a mistaken comparison in his despatch of September 16th last, in comparing a wealthy creditor country with a poor and debtor country like India. The position of France enables her to keep for internal trade purposes and requirements, such side by side circulation of gold

and silver, with the result that her standard is workmanlike, and its elasticity causes its foreign exchange to move with but infinitesimal fluctuations. Of course, a gold standard without a gold currency seems perfectly conceivable, though in a backward country like India, the greater the rarity of the coined metal representing the measure of value, the greater the zest to the proneness of its people to hoard gold, whereas such concurrent circulation would enormously obviate the risks of a shipwreck of the new policy.

Now, with respect to the fourth proposition—prohibition of silver—the experience of four and a half years following the closing of the mints, shows that despite of it no less a sum than 32 crores of rupees worth of silver was imported during the four years ending March, 1897. The total net imports were as follows, from March, 1893, to March, 1897:—

Silver 32,487,200 Rx.

Owing to the large amount of gold exported in the year 1894-5, the net imports of gold during the same four years amounted to only Rx. 484,200.

So here we have a very large amount of silver absorbed by the country, notwithstanding the closing of the mints, and the imposition of a 5 per cent. import duty. Its phenomenal cheapness is alluring, compared to the time when a rupee and a similar weight of silver were synonymous, barring seniorage; the Indian is likely to continue to take it in quantities even larger were any further drop in its gold value to ensue. In up-country districts, I understand that the bars are used to liquidate a number of transactions, in the form of barter, the Marwaree money lenders usually contriving to get the turn of the market and other pickings besides, when the ultimate holder of the bars comes to them for rupees. Seeing the rooted fondness of the people for silver, it would be interesting to consider whether, and if so how far, the virtually free influx of the metal (save for the duty) is capable of retarding the establishment of the new system on a durable basis. And if it operates in that sense, whether an embargo, or a stiff duty amounting to such, or a sliding scale varying in inverse ratio to the movements in the recorded price of the metal in London may not ultimately have to be resorted to. An arbitrary decision of this character would certainly prove vexatious to the last degree, and interfere with the time-honoured and traditional usages of an essentially conservative race. It may also constitute a

political danger of which one can scarcely measure the grave consequences. Especially so when we reflect that it has been bruited about, with more or less plausibility, that the effects of the famine were immensely enhanced by a money famine, throwing obstacles in the way of moving of grains and other foodstuffs; that it has been dinned into the minds of the natives that the suspension of coinage and consequent debasement of silver as a standard was a measure distinctly conceived with the object of saving loss to the highly-paid official classes. The moral is not difficult to draw. Such tangible grievances sink deep into the minds of the untutored and credulous ryots; the ruling authorities could not safely disregard them, or render them more acute by a wholesale decree of prohibition. Another thing to be kept in view is that such an extreme step, by still further lowering the gold value of silver, would inevitably intensify the divergence between Indian exchange and that of silver currency countries, and, as a direct result, cripple the nascent Indian industries by the aid of which so many hundreds of thousands eke out their daily existence. I have now cursorily glanced at the practical bearings of the propositions, with the simultaneous realisation of which appear to be linked the interests and the potentialities of a proximate success of the new monetary policy. Rupee prices had begun to rise, or, in other words, silver began to lose somewhat in purchasing power, the index number of the prices of Indian exports and imports in 1894 being as high as 108, as against 97 in 1892, while the very high rates of interest have caused a disturbance of, and a failure to sustain with tolerable steadiness, the level of prices, a circumstance likely to inflict injury on the prospects of production in view of the uncertainty which enshrouds the fate of the country's monetary position. Mr. Yule, the chairman of the Bank of Calcutta, mentioned to his shareholders the decision come to by several of their indigo customers, not to sow any more pending the crystallization of the Government's financial policy. If, therefore, diminished exports are to be faced in addition to the prospects of the precarious fulfilment of those conditions which are clearly necessary to the success, immediate and effective, of that policy, we do not see how, in the words of the Indian Government, "the expansion and contraction of the currency will be left to the natural forces of the market, that is, that it will be regulated automatically by the inflow and outflow of gold."

One of the gravest economic dangers to India which would attend her adoption of any form or system of a gold standard, is one which the present Government of India seems to undervalue, namely, the advantage which would permanently accrue to China and silver-using countries generally, in every branch of their industries, as regards produce or manufactured commodities, which would compete with India's produce or manufactures. From what appears in their despatch of September 16th last, it is evident the Government of India desire a gold standard with a rupee having a gold value of 1s. 4d. Now, consider from the practical business point of view, the relative effects upon India's industries and China's industries. Every rupee required to to pay fixed charges, taxes, and wages in India would cost 1s. 4d. in gold. In China, where silver in its bullion state will remain the standard of value, the gold price of a piece of silver of the weight of a rupee will, at present prices, be 10d., and therefore, speaking generally, fixed charges, taxes, and wages will cost in India 60 per cent. more than in China. Is it necessary to do more than state the case in order to prove the serious danger to India's industries and export trade, which such a condition of things would involve when made permanent by India going on a gold standard at 1s. 4d. per rupee?

It may be answered that for some time China has had an advantage to nearly the same extent, but I would remind you that trade changes slowly, as a rule, and business men like to make sure of their ground, and see that an offered advantage is likely to be permanent before they operate. Now, in the past there has been an uncertainty as to its continuance, for it has been declared again and again that the present artificial rupee system in India is a temporary experiment, and more than two years ago the Government, by the mouth of some of its most prominent members, declared that the Indian mints would be reopened if some other nations would at the same time remonetise silver, and the prospect of that consummation has till recently been considered bright. Besides, during a part of the time since the Indian mints were closed, we have had the Chinese war with Japan, with much consequent disturbance, and for a time, also, doubts were entertained as to whether foreign capital investments in China would be welcomed, and if they would be fairly dealt with. These were all good reasons why prudent business men should wait before

venturing to take advantage, to any great extent, of the favourable competitive monetary conditions which obtain in China. But, notwithstanding these reasons, considerable industrial developments have been made since the war by native and foreign capitalists, and the results, in every case, so far as I have heard, have been most satisfactory and encouraging to the investor.

The treaty which closed the war secured for foreigners rights which were before unknown, and opened channels for investments which were previously impossible; and the Chinese Government are adhering, and, as well as can be judged, intend to adhere, to the spirit as well as the letter of the treaty, and give every encouragement to foreign capital investments. It should be specially noted also, that recent political events point to a more rapid Europeanisation of that vast and populous territory than appeared possible six months ago. If India goes on to a gold standard at 1s. 4d., instead of the exchange advantages to China being the result of a temporary experiment which might at any moment be altered, they will become permanent; and as another blow would be struck at silver, it is practically certain we should see a further fall in the gold price of that metal, and, therefore, industrial India would be handicapped even to a greater extent than the 60 per cent. I have already referred to. And remember that such an advantage would not only attach to everything consumed or used in China, which India now supplies, but which China could produce or manufacture, but also to all such commodities outside China—even in India itself. For it is certain that such an economic benefit, taken advantage of as it will be to the fullest extent by British, German, French, Russian, and American capitalists, when they see its permanence assured, will not only enable China to supply itself, but also to compete successfully in neutral markets, possibly even in India. I will not attempt to go into the details of the various branches of trade which may be thus affected, but the great tea industry of India will at once suggest itself to you as having its future at stake in this matter, and the Government of India may contemplate with what equanimity it can that a further heavy blow would be struck at its opium revenue.

What position will the Government of India be in to discharge its external gold obligations if the general export trade is seriously interfered with; how will they get their land taxes paid by the handicapped ryots; and what will

be the general condition of those unfortunate ryots who are doubtless relying upon the consideration of their benevolent Government?

Let us now see how matters stand in regard to the rejected overtures made by the United States and France. The Indian Government, in their dispatch of September 16th last, left a certain loophole for harking back to them. They say, "If, however, assurances of really substantial co-operation should be secured from other countries, we shall be glad to learn their exact nature, and we shall then consider whether the promised co-operation changes the conditions of the problem, or adds materially to the chances of success."

They also said, and it is to be supposed they had an object in saying it:—"We presume that a union based upon a ratio low enough to suit our interests would be unacceptable to France and the United States." (In an immediately preceding sentence the despatch states that the true interests of India demand that the ratio should not differ greatly from 1s. 4d. the rupee.)

The United States appear by no means recalcitrant to the idea of revising the terms forming the basis of their negotiations, nor are they wedded to the old ratio, judging from the reception accorded to the declarations made before the Senate by Senator Wolcott, wherein he expressed his belief in the weight of the objections raised by the Indian Government, and went so far as to suggest the parity at the ratio of 20 to 1. Then the French Cabinet, with its powerful Prime Minister, are practically committed to the endeavour to act in concert with other powers to bring about the rehabilitation of silver in the interest of their productive industries. It may here be mentioned that their five-franc pieces, amounting to the colossal figure of £90,000,000 sterling face value, are only worth intrinsically £39,000,000 as bullion, and at present are unavailable for any but domestic purposes, whereas, at the ratio of 22 to 1 (suggested by India), they would be worth £63,000,000, and the loss of recasting them into coins at this ratio would be more than counter-balanced by their being rated universally at their bullion value.

We may now touch upon the position of this country with respect to the Franco-American proposals in connection with the re-opening of the Indian mints.

1. We were asked to hold one-fifth of our bullion reserve in the Bank of England in silver. The Bank Act of 1844 has expressly provided for it, and it was acted upon up to as late as

1870, at times when the Bank found it profitable, but it was not bound to hold one-fifth, though it was permitted to do so.

2. We were asked to purchase a certain quantity of silver annually. Very many people in the City raised the strongest objection to this, as also to the issue of 20s. notes based on silver, and to the withdrawal of the half-sovereigns (a most wasteful coin), and substituting for them 10s. notes based on silver, with limited legal tender.

Let me say, however, with regard to the purchase of silver part of the proposals, that there is a very general impression that this was inserted for the purpose of being "bartered away" in the negotiations, and with this view I am inclined to agree. At the same time, time, considering that France and the United States were proposing to open their mints to the full and unrestricted coinage of silver, with full legal tender power, it would not be unreasonable to ask this country to purchase a limited quantity of silver if only as a basis for small notes, a course for which the high authority of Mr. Goschen might be quoted. With this reservation one feels bound to confess that these proposals taken *per se*, made to a country which holds an unrivalled position as the money centre of the world, seem rather startling. The boldness of the features tones down, however, when we consider that we carry on gigantic dealings with countries interested in silver, that British investors have large sums embarked out there, and above all that the accumulated wealth of our largest dependency consists of the white metal. Really it is not asking too much to propose to this country to make a considerable contribution to the promotion of a scheme which, without in the least infringing on the effectiveness of her standard, would benefit all these interests and would fairly be carrying out the spirit of the two resolutions unanimously passed by the House of Commons under the administration of both of the great parties in the State, recognising the injury caused by the instability of silver to the best interests of this country, and urging upon the Government the advisability of doing all in their power to secure a stable par of exchange between gold and silver. However that may be, our minds must now be centred on the course to be pursued by India, which by some irony of fortune sees itself the arbiter of the situation. I ask whether India would not be well advised to take up the position of saying—that having thrown her lot on the 1s. 4d. basis, she would

if the French and American mints were opened at that ratio, agree to a scheme based upon the reopening of her mints whenever bar silver is maintained at the level of 42·86 pence per oz.—the 1s. 4d. parity. This is what Mr. Courtney, a justly recognised authority, suggested, and without wishing to play the part of a prophet, one might safely speculate on the absolute improbability, humanly speaking, of silver going below the parity to be fixed by the Union. At one stroke of the pen, the monetary equilibrium, offering immense possibilities of smoothness and stability with no troublesome periods of transition, would, it seems, most likely be secured. Of course, this suggestion is open to the obvious objection that pending the issue of the negotiations, which need not be prolonged in these days of rapid communication, business would be unsettled: the reply to that is, that it is so already, and the unsettlement in India takes the aggravated form of alternating between violent exchange fluctuations, and ruinously high rates for money.

Another point to which I would advert—though perhaps not strictly relevant to the subject-matter in hand, it goes to the root of the perennial troubles which have confronted Indian finances—is the part played by her gold liabilities in the economic development of her system of currency. I allude to this point, bristling with complexity, with extreme diffidence since such an eminent and well-known authority as Sir Robert Giffen has clothed it with the sanction of his judgment. He prefaces the main question with the dictum "that to receive for revenue in one metal and to pay in another is at most an inconvenience." An inconvenience! What a splendid euphemism this is for the tremendous financial embarrassments under which the Indian exchequer has been groaning for years, until the Government have been compelled to adopt one of the most exceptional expedients to which any Government, ancient or modern, have had to resort to face their obligations. Then Sir Robert goes on to say that "the real burdens of a gold debt can be no greater for a country with a silver money than for one with a gold money. So much gold has to be found in either case, and that gold will be found if the country has the produce to pay it with."

It is far from being the case that the real burdens of a gold debt can be no greater for a country with a silver money than for one with a gold money, or, *vice versa*, depending on the circumstances. In this statement Sir Robert leaves entirely out of sight

the fact that if there is a fixed amount of gold debt the burden will be no greater in a silver money country as compared with the same burden in a gold money country, if the gold money and the silver money continue on the same ratio. But if the two countries have the same gold debt, and gold increases in purchasing-power so that the produce that formerly was valued at £100 comes to be valued at £62 (these being the exact figures of Mr. Sauerbeck, namely, £100 as the annual average of the period 1867—1877, with a fall to £62 in 1897), then a gold debt contracted at the average of the eleven years 1867-77, will now require 61 per cent. more produce per annum at gold prices to pay the fixed amount of interest than it did when the debt was contracted, and in the event of the redemption of the principal 61 per cent. more produce will now have to be given than the money would have bought at the time it was borrowed. Thus a loan of £1,000,000 sterling contracted in 1867-77, would be paid off to-day with £1,000,000. But to pay off the £1,000,000 at to-day's gold prices, would require produce that in 1867-77 would have been valued at £1,610,000. So that by the increase in the purchasing-power of gold during the last twenty-five years, the burden in produce of the debt has increased in the proportion of £1,000,000 to £1,610,000.

On the other hand, if a silver country had in 1867-77 borrowed £1,000,000 in gold, with the Mexican dollar at 4s., it would have received in coin \$5,000,000 Mexican; but if it had to repay the £1,000,000 at 1s. 10½d., the rate of to-day, the amount of dollars required to do so would be no less than \$10,667,000. But as silver (not rupee) prices of produce are about 30 per cent. higher than they were in 1867-77, the equivalent burden in produce may be represented by \$8,200,000 as compared with the \$5,000,000 received when the loan was made.

So when Sir Robert Giffen, as quoted above, says that "so much gold has to be found in either case, and that gold will be found if the country has the produce to pay it with," he states what is perfectly true, that they have the produce with which to pay, but he omits to say that, in a case like the one taken above, the silver country has to find 113 per cent. more actual silver money than it borrowed, or 64 per cent. more produce than it borrowed. These are the increased burdens of which we have abundant reason to complain, and these are the unredressed grievances alike of the manufacturer and agriculturist in the gold and silver countries, to which they have to submit

in the interest of the holders of securities, who reap the benefit of the increase in the purchasing power of gold.

One of the greatest evils with which India has had to contend during the last 23 years has been the greatly increased amount of rupees that have been required to pay a given amount of gold debt in this country, caused by the divergence between gold and silver and latterly between gold and the rupee, owing in the case of India almost entirely to the increased purchasing power of gold, and this is really the pivot around which the interest and the action of the Indian Government are concentrated. Their object in closing the mints in 1893, when the rate was at 1s. 2½d., was to arrest the further fall, if possible, in the gold value of the rupee, so as not to require to resort to further taxation for the purpose of paying the gold obligations in London. In trying to arrest the fall, they were not altogether successful, seeing that the rate fell below 1s. 1d., but by excluding silver from the mints and thus bringing about a contraction of the currency, both actual and relative, the rate has now been pushed up to 1s. 3½d. and even 1s. 4d., though this has been accompanied by one of the severest periods of monetary stringency that India has ever known.

The Indian Government and the Home Government have doubtless been fully alive to the dangers of the monetary situation, and to the importance of placing the anomalous currency system of India on some more stable and defensible foundation. But no public declaration had been made by the Government, until the Hon. Vicary Gibbs, M.P., raised the question in the House of Commons on March 29, by moving, "That a Select Committee or Royal Commission be appointed to consider the monetary condition of India, and the effects of closing the Indian mints to silver on the different classes and interests affected thereby, to report on the suggested establishment of a gold standard in that country, and to make such recommendations as they may think fit." After the question had been dealt with by several speakers, Lord George Hamilton, the Secretary of State for India, rose and explained the views of the Government. In regard to the opening of the mints the opinion of the Government was that any such attempt, "without some international arrangement being come to would be an act of lunacy." He said that he "should be sorry to be a party to inquiry into the Indian monetary system if it were believed that he in any way associated himself with the

idea that that inquiry would lead to a reversal of the policy established in 1893." He declined to accept Mr. Gibbs's motion, but while rejecting the recommendation to appoint either a Select Committee or a Royal Commission, for reasons that he stated, he nevertheless consented to the appointment of "a committee, not being a departmental committee in the sense of being composed mainly of officials in the India Office, but one having all the powers and all the attributes of a Royal Commission, and which is simply put in the shape of a committee because this is a handier—and, he thought, a more effective—instrument of inquiry."

The House agreed to the proposal of the Secretary of State, and it may be expected that the terms of reference will enable the whole question of India's monetary system to be thoroughly and practically examined. We know, from what has been officially published, that the Indian Government desire a gold standard, and that the rate they wish fixed is a rupee equivalent to 1s. 4d. in gold. The other features of the scheme have either not taken shape yet or they are withheld for the present, so that it is impossible to say whether there is any really practical method of providing an automatic system which will give an effective gold standard for India. Now, at least, the whole subject will be carefully investigated, and knowing as I do the difficulties that lie in the path of the Indian Government, I shall not attempt to prejudge the results of this investigation. I shall merely express the hope that the outcome of the deliberations of the Committee will prove to be a benefit to India by the recommendation of some system that will put an end to the currency uncertainties of the last few years, that will restore confidence to discontented communities and put an end to the causes of the serious monetary stringencies that have been so disastrous, and that will bring prosperity and contentment to the great mass of the people of India.

In conclusion, I beg to thank you for the extreme patience and forbearance you have shown in listening to what I fear has been a long and somewhat tedious paper, but I venture to hope that I have advanced no argument in any spirit of arid dogmatism but rather in that of anxious inquiry, and that the paper will gain some brilliancy from the reflected ability of those who may be disposed to take part in the discussion of the several points raised therein.

DISCUSSION.

The CHAIRMAN, in proposing a vote of thanks to Sir Edward Sassoon for his very valuable paper, said there were a few observations he should like to make before inviting a general discussion. In the first place he hoped they would all imitate the example set by the reader of the paper, and treat this matter with good temper. It was unfortunate that so abstract a subject as the currency question should produce so much ill-temper, and it was their duty to struggle against that tendency. He would also ask especially that the Government of India and Sir James Westland should be treated with all possible consideration. They did not take the matter up out of lightness of heart, but because by their positions they were bound to come to some decision on this question, and though his friend, Sir James Westland, was, he believed, made of sterner stuff than himself, if Sir James suffered half as much lately as the present speaker did in the six months before the mints were closed, he deserved compassion and not censure, whatever his proposals might be. There were also a few matters he might explain with regard to which there appeared to be some confusion. It was not the case that after the Herschell Committee closed its proceedings the Government of India was at liberty to delay closing the mints while they negotiated with other Powers. The decision was then finally come to to close the Indian mints, and to attempt to introduce a gold standard. They could not say we will not close the mints for the present, and hold out a threat of doing so to other nations whilst negotiating with them with a view to coming to some other arrangement. The mints were closed to the free coinage of silver, with the intention of ultimately establishing a gold standard. As far as he was aware the Government did not finally decide what should be the next step; it waited to see the result, and reserved to itself the right to take such steps as might appear necessary. Certainly the Government had not accepted any proposals of his, or come to any final conclusion as to what should be done; nor did it decide at that time that the ratio at which the gold standard should be introduced would be 1s. 4d. That figure of 1s. 4d. was introduced into the discussion in this way. The Herschell Committee thought that on the first closing of the mints there might be a dangerous rise in the rate of exchange, and as a matter of precaution suggested 1s. 4d. as the point at which rupees would be given for gold so as to prevent any dangerous and sudden rise; but it was still open to the Government of India, or to the Secretary of State, to choose 1s., 1s. 4d., 1s. 6d., or 1s. 8d. He did not know whether they had finally come to any decision, but the tendency had been towards the adoption of 1s. 4d. Still that figure had never been formally laid down as the rate at which the gold standard should be introduced. There was another matter on which a little explanation might be useful. It had been said

that a statement was once made by him that £15,000,000 sterling in gold would be sufficient to maintain the gold standard in India. Now he did not mean that if you took £15,000,000 either by borrowing or in any other way, and added them to the Indian currency, the gold standard would be secure for all time; he meant that if the gold standard were introduced, and the rupee currency reduced as far as necessary to arrive at a rate of (say) 1s. 4d., and that figure became the normal rate of exchange for the time, then with the reserve of £15,000,000 in the active currency passing from hand to hand he should look on the gold standard as reasonably secure. With regard to the general discussion, he would suggest the importance of bringing forward new facts if they were available. They had had a great deal of theory, and what they wanted now were facts as regarded the position in India since the mints were closed. One important question was whether the present high rate of exchange was likely to be maintained, and in arriving at a decision on that point they must decide whether the present high rate of discount was due to a positive scarcity of rupees or to a want of loanable capital. If it were due to a positive scarcity of rupees then they were on the eve of the establishment of a gold standard, for as rupees became scarcer the rate of exchange must continue at 1s. 4d. For his part he did not believe that the high rate of discount in India was due to an actual want of rupees but rather to a want of loanable capital. It was well known that bankers had for many years kept as little capital as possible in India, withdrawing it from there because they lost by keeping it in silver. It was also known that many persons had taken advantage of the recent high rate of exchange to get their money home from India, and he believed some banks had done the same. It was also the case that there had been a good deal of borrowing in India, and there must have been a good deal of capital taken away from the Presidency towns and centres owing to the famine. Another cause which a banker, in whose opinion he had confidence, thought was operative was this: in former times when silver was sent out in large quantities to India it was coined into rupees; it was then sent into the banks and found its way gradually into the country; during its temporary stay in the banks it was available to meet the wants of business; but if it went out as uncoined silver, and remained uncoined, it was not available for the wants of trade when there happened to be pressure for money. Capital was very cheap in this country, and the question was why did it not go to India. The reason was that the public were not confident that the present rate of exchange would be maintained, otherwise they would certainly rather lend their money at 12 per cent. in Calcutta than 3 or 4 per cent. in this country. There was another point on which information would be very valuable. What became of the large imports of silver into India at the present time? It seemed

probable that they were simply absorbed in the ordinary way by the country, and there was a large amount going there now. It would be also useful if anyone could give information with regard to the condition of the currency in native States which had the power of coining. Some had accepted the Indian rupee, Cashmere for instance, and when he left India there was some talk of the coinage of silver being stopped in certain States, but in other States it was possible that silver was still being freely coined. One would like to know the condition of the currency in the chief native States, such as Hyderabad, Scindia's Territory, and the Great Rajpoot States; had they gone on coining, or had they stopped, and how was trade carried on between British territory, where an artificial rupee was current, and those States where there was another artificial rupee or perhaps a natural rupee current. It had been suggested that uncoined silver was used to a large extent as a circulating medium, but he doubted it. A ryot might conceivably sell his wheat for raw silver, but if he took the bar silver to the Government Treasury to pay his revenue he would soon find his mistake. Then the question was how far it had been a hardship on the owners of hoarded silver that that silver was now of less value than formerly in comparison with the rupee. He was not satisfied that it was a very serious evil in practice, because most people who owned uncoined silver did not hold it for the purpose of selling, but to use it for ornament or simply to hoard it. Of course, the hardship fell on them when they came to sell it or borrow money on it, but one would like to know to what extent that hardship was actually experienced. Only a very small percentage of the people ever sold their uncoined silver. The great difficulty in introducing a gold standard was the enormous mass of coined rupees in existence. If it should prove to be the case that these rupees were thrown generally into the currency, the cost of introducing the gold standard would be practically enormous, as all these rupees would have to be absorbed. On the other hand, if they were not thrown into the circulation the operation would become much more easy, and it would be still more easy if people went on hoarding rupees, even under present conditions. There would be a natural process at work to reduce the circulation, and the introduction of the gold standard would be by no means impossible. He was not offering any opinion whether it was desirable or not. Some people said if a gold standard were introduced enormous quantities of gold would be brought out from hoards of private persons and used as a circulating medium. He wished to speak with consideration of his opponents, but if anybody made a statement of that sort, in his opinion he was not merely incorrect, but a man whose opinion you had better avoid taking on anything in connection with the currency. If a silver standard were introduced into this country, would the people who had silver teapots and other articles of plate melt them down

and throw them into the circulation? The thing was absurd. Of course, they did not know much about Indian ladies, who usually lived in the seclusion of the zenana, but he believed they had as much influence in families as the ladies in this country, which was saying a great deal, and if an Indian went to his wife and told her that the Government had made gold a legal tender, that he proposed to melt down her gold bracelets, and put them into circulation, he did not think he would meet with a very favourable reception. What might be expected to happen and what would happen when gold began to circulate as a portion of the Indian currency would be that there would be a greater tendency to withdraw it and hoard it. A native banker, for instance, would say, "I can get £1,000 sterling for so many rupees at the present time, and as the exchange may go to 1s. 3d., and the £1,000 be worth more rupees, I will take that £1,000 and keep it in a box and let the rupees circulate." Therefore, in the first instance, any gold that went into the Indian Treasury would be at times withdrawn, but it did not follow necessarily that the process would be carried on to such an extent that a gold standard would become impossible. Still it was a thing which had to be reckoned with.

Sir SAMUEL MONTAGU, Bart., M.P., said it was very difficult to find anything new to say on this subject. He agreed with almost everything to be found in the paper, and had no doubt the information brought forward would be made use of in the inquiry about to be made. The Government had, of course, the usual three courses open. They might allow matters to drift as they were doing now; they could open the mints; or they could persist in their policy of a gold currency for India. They were all agreed in condemning the existing state of things, for to leave a great country without any metallic standard at all must be prejudicial, and some remedy must be found. Most of his friends who were in favour of bimetallism agreed with him that the only perfect solution would be international bimetallism at a reasonable ratio. When he was on the Royal Commission some years ago, he suggested 20 to 1; now they had arrived at 22 to 1. Sir Edward Sassoon had put forward very forcibly the position in which France stood, because under the international arrangement, it was only France which blocked the way. As he put it, they had £90,000,000 sterling nominal value of five-franc pieces, worth at the present rate of silver £39,000,000. He held that would be quite unsaleable at the price, but that was another question. That left £51,000,000 *del credere*, the credit obtained by the Government by affixing the Government stamp on pieces of silver. Through making it a legal tender they had an excess, or *del credere* value of £51,000,000 sterling. If they were to adopt the international agreement proposed by the United States, and take 22 to 1 as the ratio, which would be agreed upon by the Indian Government,

he hoped those five-franc pieces would be worth £63,000,000, as a really valuable asset, leaving only £27,000,000 *del credere*, which could easily be filled up by the printing press, because if a Government gained credit in one way by stamping coin, it could get the same amount of credit by issuing Treasury notes. Anybody who took a five-franc piece, knowing it was not worth more than two francs, trusted the French Government to three francs. On one point he did not agree with Sir Edward Sassoon, namely, as to the possible withdrawal of half-sovereigns. A wealthy country like this could put up with the inconvenience of having half-sovereigns. He should not like to have to walk about with 19s. of silver in his pocket. No greater fallacy could have been propounded by Mr. Goschen than to think there was any difference between notes based on silver and notes based on gold. Even in the United States certificates, although stated to be payable only in silver, were payable really in gold, because they could be tendered to the Government in payment of duties or taxes. So it would be if we had 10s. notes or £1 notes based on silver. If they did not want silver, all they would have to do would be to pay their taxes with it; but it would not be very useful for this country to buy a quantity of silver, or for the Bank of England to hold, as she was permitted, one-fifth of the reserve in silver, unless it were on account of the Indian Government. Certainly the Bank of England in this country ought to be protected from any result of a large holding of silver when it would be done almost entirely for the benefit of India. What ought our answer be to France, the country which blocked the way to an international standard for silver. Even bimetallists could not beg and beseech France to alter her course. The Indian Government ought to persist in establishing a gold currency until France came to reason. He did not think with the splendid credit which India enjoyed, and which he hoped she always would enjoy, it would be very difficult to collect the amount of gold necessary for her to establish, at any rate for the time being, a gold currency. If they had international bimetallism there must be gold also in India, and he thought the Indian Government could accumulate gold. He would ask the Chairman whether it would be possible to exact the whole or a portion of the land tax, say, from the large holders of land, not the small ones, in gold. Russia had accumulated an immense amount of gold by making the customs duty payable in that metal. In an enormous country like India he should think there were means of getting gold into the country without the necessity of actually borrowing it, but not being intimately acquainted with the customs in India he could not give an authoritative opinion upon that.

Mr. STEPHEN RALLI said the question under discussion was a most difficult one, but there was no doubt India could not go on under the present system. The Government were very well advised when they decided to appoint a Departmental Com-

mittee, and he hoped their endeavours to put Indian finance on a sound footing would be successful. India was not like France, it was a debtor country to a very large extent. The amount which India had to remit to the Government at home amounted to about £18,500,000, besides which she had to remit to private individuals or companies £7,000,000 or £8,000,000 sterling, being the profit on European capital invested there. How could India pay that debt to England? It could only be done by the excess of exports over imports. Therefore the Indian Government must do what they can to increase the exports as much as possible. On what did the exports depend. First on whether the crops were abundant, moderate, or deficient; secondly, on the value in the selling markets of the various articles exported from India; and, thirdly, on the relative cost of the same articles in competing exporting countries. Now the opinion of most competent Indian merchants was that in order to make exports as cheap as possible there must be a low rate of exchange. Sir Edward Sassoon had spoken of China, and that was the most important feature of to-day, so great, that he was afraid that the consequences to India within the next ten years would be very serious. The Government had very cleverly taken under their wing the central provinces of China. Those immense provinces were very fertile, and contained an immense population of active and industrious workers who were not paid more than Indian workers, and were infinitely superior to them. The future of those countries was immense under English protection, because sooner or later it would come to that. He hoped the English Government would select some of their Indian officials, for whose abilities and administrative capacity he had the very highest respect, to send to the central provinces of China to assist the Chinese Government. Under such men life and property would be safe, and the exactions of the mandarins, which now prevented all progress, would be very much restricted if not abolished. All the articles of export from India with the exception of a few, would be cultivated in China; cotton, wool, and jute mills would swarm there. The cotton cultivation of China would immensely increase, and what would be the result on the cotton mills in Bombay. They must feel the competition very much. Then again, the tea trade in India and Ceylon had immensely increased of late years, because it was under European management, and the same thing would now take place in China. The competition with China, therefore, in ten years would be very great, and would be felt in India, as they had already felt the competition of Chinese opium. China would have an immense advantage over India, as had been pointed out in the paper. The advantage of the interchange being on a silver basis, the exchange would be about 10d., whereas in India they were strangled by the 1s. 4d. exchange. He was very much afraid, therefore, that unless the exchange were lowered India would be under a great disadvantage. What was the position in

India with regard to exports? This year there had been a large export of wheat from India; first, because the crops were abundant; secondly and principally, because the price was very high; but in normal years India had ceased to be a factor in the export trade, because America grew wheat to an immense extent, Russia had extended immensely her wheat exportation, and Argentina the same, and as during late years the price of wheat had been low, India had almost ceased to export it, because she could not compete at such low prices with other countries. Linseed again was a very large article of export. Some years ago the exportation from Calcutta and Bombay was 500,000 tons, but, in 1896, Russia alone exported 700,000 tons, owing to the increased cultivation in the Caucasian provinces. India also had to compete in this respect with the Argentine Republic. Cotton was a very large article of export from India, and it remained about the same, but America exported about 11,000,000 bales, and at the present price of American cotton at 3½d. it was difficult for India to compete. Therefore, unless the English Government was alive to the necessity of a low exchange, the future of India was very critical. He would now endeavour to prove the influence of the exchange on the export trade. A friend of his, a great political economist, Lord Farrer, in conversation with him, maintained that the rate of exchange had nothing to do with the exports of a country, but if Lord Farrer and several clever men who agreed with him had served for a few years in a commercial firm, and had seen practically how the prices were affected by the rate of exchange, and what influence it had on the cultivation and exports of a country, he would be of quite a different opinion. The difference between Lord Farrer and himself was this—that Lord Farrer was a theorist, and he was a practical man. He pointed that out to Lord Farrer, and to his late friend, Mr. Currie, and told him that in his experience in London, which dated from 1851, those who deduced conclusions from theories, and applied them to business transactions, were almost sure to go wrong. Since that time all the merchants who were strong in statistics, men of great ability who deduced conclusions from theories and applied them to their commercial pursuits, had gone to the wall. Suppose the exchange to be 1s. 4d., at the present value in Europe of any article he could give to the native producer (say) 12 rupees. Then, if the exchange were 12d., he could give to the producer 16 rupees instead of 12. Now as wages in India only changed very slowly, the cost of production was about the same, whether the exchange was 1s. 4d. or 12d., and, therefore, how could it be maintained that, if he gave the native 16 rupees instead of 12, he would not make more money and increase his cultivation and export. Again, by increasing the exports, you created a much larger demand for imports, because when the agriculturists of India were prosperous, as a matter of course they would buy more

European goods. Therefore, a low exchange favoured exportation directly and importation indirectly. He was sure the Chairman would bear him out in stating that when the exchange was 2s. or 1s. 11d., the Government of India had great difficulty to make both ends meet, and that during those years, when the exchange declined, the prosperity of India so improved that the budget was much better than when the exchange was higher. The Chairman asked if any evidence could be given of the scarcity of rupees. Not long ago he was asked the same question by a friend, and made some inquiries. Moulmein was a large exporting country, from which a great deal of rice was shipped. His friend, Mr. Herbert Arbuthnot, told him that Messrs. So-and-so, of Moulmein, wrote him that the scarcity of rupees was so great that whereas they had to pay an export duty of 21,000 rupees on a cargo of rice they were shipping it was impossible to find the money. That information was transmitted to a Minister, who challenged him for proof of the statement. He sent him a copy of the letter with the name of the firm, and the name of the ship, and the additional information that they had to bring rupees from Calcutta. Many exporting merchants paid willingly 20 per cent. interest per annum. It was well known in Bombay, Calcutta, and Kurrachee that rupees were scarce. How could they not be when the Government had ceased coining, and over and above there was the wear and tear of the circulation. Then another question was asked—what became of the silver going to the native States? The general opinion in India on this point was that there was a good deal of illicit coinage. It was true that up to the present time the illicit coinage in circulation did not appear to be great; some said it was 2 per cent., but it was probably $\frac{1}{2}$ per cent., and these illicit rupees were so well made that it was impossible to detect them even when sent to the mint. How could illicit coinage be prevented in native States? The proposition now was a gold standard, either with a gold coinage or without. He maintained that if the great mistake which had been made was continued, and if the rate of exchange remained at 1s. 4d., whether you had a gold coinage or not, gold would disappear. There were factors to take into consideration. There were not always abundant crops as there had been this year, but the tribute or debt of India to England must be paid by export, and, therefore, if the crops were deficient, India must export gold. Secondly, immediately the Indian princes and bankers would hear that Her Majesty's Government had decided to have a gold standard they would think the Government had lost confidence in rupees, and those men who had millions sterling of rupees hoarded would rush to the Treasury and change their rupees for gold. Mr. Lindsay thought that if the reserve were in London it would not have the same effect as if it was in India, but that was a fallacy, because they would buy exchange from the Government at 1s. 3 $\frac{1}{4}$ d., send the bills to London,

and get the gold in India. Unless the exchange were much lower, and trade developed, the gold standard would fail.

Sir WILLIAM HOULDSWORTH, Bart., M.P., said this was an Indian question, and having no Indian experience, he would only say that he thought they were deeply indebted to Sir Edward for his clear and excellent paper. He was glad that in one sentence he threw aside the judicial function he had assumed, and advocated international bimetalism as the only true remedy for the difficulties of the Indian Government and people. The Indian currency question really meant the want of a settled par of exchange between the money of India and the money outside India, and there seemed to be only two ways of dealing with it. One way was to make the money of India the same money precisely as the money outside. They could do that, or could attempt it, with regard to England and gold-using countries, by having a gold standard, but that did not cover the ground, even if it were possible, because there was still China and other countries on the silver standard which would not be covered. He thought it very opportune that this discussion should be taking place when the Committee was about to sit on the question, because it was exceedingly important that public opinion should be educated upon it. After all, the Committee, able as it might be, would be dependent on the information and the arguments and the views which were presented to it by the witnesses, and by public opinion outside, and, therefore, he hoped meetings of this kind would be continued, so that without attempting to bring any undue pressure on the Committee, it might be thoroughly informed as to the opinion of experts and practical men on this question.

The CHAIRMAN, in putting the vote of thanks, said, with reference to Sir Samuel Montagu's inquiry, that it was quite impossible that large landowners in India could be called upon to pay the land revenue in gold in order to accumulate a reserve. It was quite possible to levy customs duty in gold, but he doubted whether Manchester would like it. With regard to the scarcity of rupees he was not satisfied even on the evidence Mr. Ralli brought forward, that the scarcity at Moulmein was not due to the scarcity of capital for the time being. As regards illicit coinage in good silver, he had not seen any evidence that it existed, but if it did become very prevalent, the scarcity of rupees would disappear.

The vote of thanks having been carried unanimously,

Sir EDWARD SASSOON, in reply, said:—It only remains for me to say how much I appreciate your kindness in passing the vote of thanks to me. We have been fortunate enough to elicit useful and valuable declarations from Sir David Barbour on points which had been variously interpreted, and not

the least of them you will think is the disclosure of the adamant nature of his successor's disposition, so that we merchants and bankers, when we are harassed and wearied by the troubles and vagaries of an inscrutable and unfathomable exchange, now know that we can turn round and peg away at some one with impunity.

TWENTIETH ORDINARY MEETING.

Wednesday, May 11, 1898; CORBET WOODALL, M.Inst.C.E., in the chair.

The following candidate was proposed for election as a member of the Society:—

King, Brig. Surg. Lt.-Col. Sir George, K.C.I.E., LL.D., F.R.S., care of Messrs. Grindlay and Co., 55, Parliament-street, S.W.

The following candidates were balloted for and duly elected members of the Society:—

Carnegie, Douglas, M.A., 84, Shooters's-hill-road, Blackheath, S.E.

Cleghorn, Robert Cooper, 14, St. Mary-axe, E.C.

Davis, Harold, Belle-vue-house, Park-place, Greenwich, S.E.

Farmer, Henry, 5, Royal - terrace, Portishead, Somerset.

Skrine, Francis Henry, Queen Anne's-mansions, S.W.

Smith, George Henry, Brookeland, New Malden, Surrey.

Stroud, Prof. Henry, M.A., D.Sc., Durham College of Science, Newcastle-on-Tyne.

Williams, Stephen M. J. (Bengal Nagpur Railway), care of Messrs. Grindlay and Company, Calcutta.

The CHAIRMAN, in introducing Professor Lewes, said that it was twenty years since he had the honour of occupying the position of Chairman at one of these meetings, when Dr. William Wallace read a paper on "Gas Illumination." It had been his (the Chairman's) lot to initiate a system of lighting public ways by better lanterns and burners, which had received a large acceptance, and had shown that, in point of economy, efficiency, and picturesque effect, gas was still able to hold its own for this purpose. Electricity was just then coming into notice for purposes of illumination, and they were assured by many that, if not already on the descending scale, gas-lighting had reached its maximum. In the year 1878, the consumption of gas in London was about 11½ thousand million feet; to-day it was, as nearly as possible, double that, and, as far as one could see, the prospects of advance were as bright now as they were at the period he referred to. Whether that result had at all been brought about by the efforts of a friend disguised as an enemy it was not worth while to argue, but he claimed at any rate

that the period had been one of so much activity as made it remarkable in the history of the gas industry. In those advances they had always found Professor Lewes ready and willing to help. At that time they were satisfied to obtain by burning gas at the rate of 5 feet per hour a light equal to 15 candles, or, roughly, 3 candles per cubic foot. Since then the rate had advanced 10 candles per foot, and to-day, thanks to the charming invention of Dr. Auer von Welsbach, they were able to realise 25 candles per cubic foot, or an increase of 8 times in illuminating effect, with the incidental advantage of removing in great measure the nuisance of smoke. In the process of manufacture probably the greatest advance of recent years had been that which was about to be explained. The introduction of carburetted water gas had come at a very appropriate period, when with the demand for improved lighting there had been also a diminution in the supply of high-class coals and cannels suitable for making gas of high quality. From 1889, when he had the opportunity of investigating this new process in the United States, until now, he had been actively connected with this branch of the industry, and he had seen nothing but reason for thankfulness at its introduction and increasing satisfaction with the results. It had not only been satisfactory to the manufacturer, but also yielded to the consumer a better, brighter, and purer light.

The paper read was—

WATER GAS AND ITS APPLICATIONS.

BY VIVIAN B. LEWES,

Professor of Chemistry, Royal Naval College, Greenwich.

The history of nearly all commercial processes shows us how rarely success is at once attained, the skeleton cupboard of the manufacturer containing many gruesome records of hard-fought struggles and failures before the discovery of some small alteration in the process has elevated it from the depths of mediocrity to the heights of success; and when in the future the history of water gas comes to be written, it will be found to be no exception.

The latter half of the last century, which was so rich in scientific discovery, saw the first recognition of the fact that when steam is passed through red-hot carbon in any of its many forms, an inflammable gas is produced. This discovery is generally attributed to Fontana, and the fact was certainly well known to Lavoisier and the brilliant band of scientists whose labours will ever render this period one of the most notable in scientific history, but it was not until 1824 that any attempt was made to adopt the action to commercial requirements. In this year Mr.

Ibbetson conceived the idea that the volume of illuminating gas could be largely increased by passing steam through the hot coke left in the retorts after the carbonisation of the coal had been completed, the gas so produced passing on and mingling with the coal gas.

It was soon found, however, that the temperature of the carbonaceous matter was too low, and that the large quantities of carbon dioxide produced utterly ruined the illuminating power of the coal gas, and although Ibbetson's idea has been patented many times since that date, the same cause has always led, and must always lead, to failure.

The reason for this is that at a high temperature the action of the steam upon the carbon is to yield a mixture of equal volumes of carbon monoxide and hydrogen, both inflammable gases, whilst the action which decomposes the steam also rapidly reduces the temperature of the carbon, and the moment this falls below a certain point, if the quantity of steam be kept constant, carbon dioxide begins to appear in the place of carbon monoxide, and as this gas is the most fatal of any known gas to the development of light in flames which owe their luminosity to the separation of carbon particles, its presence in any large quantity must of necessity ruin the quality of the coal gas with which it is mixed.

The value of water gas for all purposes depends upon the carbon dioxide being kept down to the lowest limits commercially possible, and its average composition may be taken as:—

Hydrogen	51·89
Carbon monoxide	40·08
Carbon dioxide	4·80
Methane	0·10
Nitrogen	3·13
	100·00

The figures given being the average of many analyses.

Six years after Ibbetson's experiment, Mr. Donovan attempted to make carburetted water gas as a substitute for coal gas, and did so by passing steam through coke heated to a high temperature in a retort, and passing the resulting water gas into a second chamber, where it was brought into contact with crude hydrocarbons, such as tar or naphthalene. Failure attended this attempt, and also many others which were made during the next twenty years, but in 1849 another important step towards success was made by Gillard, who at Narbonne

introduced a sort of cupola furnace for the manufacture of water gas, and adopted the entirely new idea of raising the temperature of his carbonaceous fuel by blasting it with air instead of heating it in a retort fired from without, and having raised the fuel to incandescence by his air blast, he then shut off the air and passed steam through the fuel, until the temperature was so reduced as to necessitate a fresh blowing up by air, and it is this method of "blow and run" which has since been employed in all the water-gas processes which have had any claims to success.

After Gillard's time numerous other attempts were made to introduce water-gas processes, but nothing of importance was done until 1875, when Lowe and Tessié du Mothay in America inaugurated the present carburetted water-gas systems, which are now as genuine a success here as in the land of their birth.

Fuel gas had long been used in many metallurgical operations, and had been produced in various forms of apparatus by blowing air through a bed of incandescent fuel, an operation which yielded an impure mixture of carbon monoxide with the residual nitrogen from the air, having the average composition—

Nitrogen	64·5
Carbon monoxide	29·0
Carbon dioxide	4·0
Hydrogen	2·5

But as this usually contained only some 30 per cent. of combustible matter, its heating power was very low, and attempts had been made to improve its composition by using soft coal instead of coke, or by mixing a little steam with the air before passing it into the fuel.

It was not unnatural, therefore, that as processes for the production of water gas appeared to be nearing a commercial status of success, attempts should be made to utilise this valuable heating gas for fuel purposes, as by its aid great intensity of heat could be obtained, its heating value being four times as great as the air-coke fuel gas, and from two or three times as great as the improved fuel gases.

With this object in view, several Continental works set up plant on the "blow and run" principle, the most successful being the form adopted by Messrs. Schultz Knaut and Company at Essen, who employ the gas largely and successfully for welding tubular boilers and lighting by incandescent devices.

The form of apparatus installed by them, which is still in use, consists of what is practically a cupola furnace lined with fire-

brick and with a constriction a short distance above the hearth, the firebrick being protected at this point by a water-cooled ring, the usual size of the generator being about 20 feet in height and 7 feet in diameter. An air blast is admitted below the water-cooled ring, and by blasting for about 10 minutes, the ignited fuel is raised to incandescence. The air blast is then cut off, steam is admitted above the top of the fuel, and passing down through it becomes converted into water gas which escapes by the same opening as that through which the air blast was admitted, this being opened and closed by means of a water-cooled valve slide of such construction that it is impossible for any explosive mixture of water gas and air to be formed. The water gas passes on to the purifiers, which remove sulphuretted hydrogen and carbon dioxide, and the gas is then stored in the gas holders. The fuel is fed into the generator by means of an orifice at the top, which is closed by a cone; the whole of the steam, air and water-gas pipes being governed by an arrangement which renders any explosive mixture impossible.

Hearing of the success of this installation, Mr. Samson Fox, after having the process investigated, acquired the British rights to the patents covering this and the other processes then in use, and erected an installation at the Leeds Forge, in 1887, which was started in 1888, and proved as successful for the particular class of work done there as it had been at Essen. This was followed by the exploitation of water gas, and the events of 1889 in connection with it, but any chance which water gas had of being made a general success was entirely swamped by the public disgust at the jobbery in connection with the floatation of the water-gas companies, and this feeling being accentuated by a deplorable accident at the Leeds Forge consequent on a leakage of the highly poisonous gas, this chapter in its history ended in disastrous failure and heavy loss to the public.

In the meantime, however, events in the gas world had gradually been opening up a field for carburetted water gas as an auxiliary to coal gas, and the price to which the cannel coal used for the enrichment of coal gas had risen caused the gas managers of this country to look into the advances which carburetted water gas had been making in America, and this resulted in the adoption in many works of the gaseous mixture which up to that time had been looked upon as a rival. At the present moment at least one-fifth of the gas supply to London north of the Thames consists of car-

buretted water gas, whilst many of the large towns in the Midlands have followed the lead of the metropolis, and at the present time there is in England alone plant capable of turning out over 70,000,000 cubic feet of carburetted water gas a day.

The prejudice which at first existed against the introduction of carburetted water gas is gradually growing more and more feeble, and it is generally recognised that when used with not less than its own volume of coal gas the danger of poisoning from its use is very small, save under conditions which would make coal gas itself dangerous to life.

At this point it will be well to consider the economic conditions which up to the present have prevented pure water gas from coming into general use, whilst when carburetted it has achieved so remarkable a success.

In making water gas by such processes as those employed at Essen and the Leeds Forge, fuel in the cupola is first raised to incandescence by the combustion of a portion of it under the influence of an air blast, an operation giving as a gaseous product the so-called air-coke gas, an analysis of which has already been given.

Before the temperature of the fuel has been raised to a sufficient point to enable 1,000 cubic feet of water gas to be made by steam injection, no less than 4,000 cubic feet of this air-coke or producer gas has to be formed, and this quantity contains over 44 lbs. of carbon taken from the fuel; the 1,000 cubic feet of water gas are then made and contain a little over 15 lbs. of carbon, so that the production of the 1,000 cubic feet of water gas means an expenditure in round numbers of 60 lbs. of carbon.

These figures are calculated from the analysis of the water gas and producer gas, but they are amply verified by the fact that if the percentage of carbon in the coke used be taken in lbs. per ton and be then divided by 60, you will obtain figures coming within a few cubic feet either way of the actual yield of water gas obtained from the particular quality of coke.

What that means is shown in the Table on the next page.

In practice results of several years working give an average of 34,000 cubic feet of water gas per ton of coke.

Some observers have given lower figures than these, but that has been due to canal coke forming a large proportion of the fuel used, and, with a dirty and very crumbly coke,

a longer blow has to be made in order to obtain the required temperature.

Percentage of Carbon in Coke. Per cent.	Pounds per Ton.	Water Gas from a Ton of the Coke. Cubic feet.
84	1,859.2	30,986
85	1,904	31,733
87	1,948.8	32,480
90	2,016	33,600
92	2,060.8	34,346
95	2,128	35,466
100	2,240	37,333

A thousand cubic feet of water gas contains as the combustible constituents—

Hydrogen..... 2.75 lbs.
 *Carbon monoxide..... 30 lbs.

and the thermal value will be represented by

$$(2.75 \times 34,400) + (30 \times 2,400) = 155,600 \text{ T.U.}$$

The thermal value, however, of the 60 lbs. of carbon used in making the water gas would be

$$8,080 \times 60 = 484,800.$$

In other words, the water gas formed has only a little over 34 per cent. of the heating value of the carbon from which it has been formed, and this loss of over 65 per cent. of the calorific value has rendered the use of water gas, save for special purposes, impossible.

Where, however, the air-coke or producer gas can be at once led away, and burnt whilst hot for any purpose, another 223,328 thermal units will be produced, bringing the total calorific value of the two gaseous mixtures up to 80 per cent. of the value of the carbon used in generating them.

If these conditions could have been satisfied, there is no doubt that water gas would have been highly successful, but inasmuch as the producer gas is four times greater in volume than the water gas made, and as the gases are produced intermittently and not continuously, the problem of utilising both of them was an almost insurmountable difficulty, as if storage had been provided for the producer gas, the gas-holder room required would have been enormous, whilst allowing it to cool down would have rendered it hardly worth burning. In some few installations, a portion of the producer gas has been successfully used in firing boilers and other work of the same character, but the difficulties before enumerated

have been so great that they practically killed the general utilisation of water gas for fuel purposes.

When the manufacture of carburetted water gas was first successfully carried out by Lowe and Tessié du Mothay, it became at once apparent that the producer gas, the loss of which had crippled all water-gas processes, could be utilised for raising chambers filled with chequer-brickwork to a high temperature in order to decompose the oils to yield the oil gas which, mixed with the water gas, rendered the water gas luminous; and it was in this way, by making the carburetted water-gas plant a perfect heat machine, that its greatest success was achieved, as in raising the fuel to incandescence the producer gas, with all its heat in it, was at once burnt with a fresh supply of air in the superheating chambers, the practical loss of heat taking place throughout the whole apparatus being reduced to a minimum.

In England at the present time the apparatus used for the manufacture of carburetted water gas is made on what is known as the "Improved Lowe System," or a modification of it. The apparatus consists of a firebrick-lined generator, connected both and below the fuel bed with the top of the carburetter, which is also lined with firebrick, the bottom of which is connected laterally with the adjoining superheater. The carburetting and superheating chambers are filled with a chequer-work of brick, and at the top of the superheater is a valve for giving exit to the products of the blasting. During the "run" this valve is closed, and the carburetted water gas is sent on to the scrubbers and purifiers by a side pipe. The oil used for carburetting the gas, is usually that known as the Russian "solar distillate;" after having been heated by waste gases from the superheater, it is led into the carburetter, where it is introduced in the form of an atomised spray at right angles to the cross-section of the carburetter.

The method of working is as follows. An air blast is forced through the fuel in the generator, raising it to incandescence, whilst the products pass on through the carburetter and superheater, and, meeting a regulated air supply, are burnt off and heat up the chequer-brickwork, after which the products of combustion are allowed to escape into the chimney stack. When the fuel is properly incandescent, and the superheater and carburetter at the required temperature, the air blast is shut off, the exit valve in the carburetter closed, and steam admitted over or under the fuel bed. The result-

* Although 15 lbs. of carbon are present in the water gas, some of this is in the form of carbon dioxide.

ing water gas passes to the carburetter, where it meets with the oil gas produced by the oil heated in the chequer-work, and travels on to the condensers and scrubbers. After a time the temperature of the fuel in the generator falls, when the steam is cut off, and the fuel is again rendered incandescent by the air blast.

This form of apparatus, and all allied ones, for making carburetted water gas, have given the only marked success for the commercial utilisation of this gas, and this success must be put down to the doing away of the enormous loss which, owing to the waste of the producer gas, the other processes necessitated.

In all the attempts to make water gas which had seen the light up to last year, the raising of the fuel to incandescence has practically always been obtained by using the air blast in so deep a bed of fuel that the carbon monoxide and residual nitrogen of the air formed the chief resultant products, and it must be remembered that when 1 lb. of carbon combines with oxygen to form carbon monoxide, as when forming producer gas, only 2,400 heat-units are developed, whilst if air be present in sufficient quantity to burn the carbon direct to carbon dioxide, the amount of heat which is evolved is 3.37 times as great, that is, 1 lb. of carbon gives 8,080 heat-units. A process for making water gas has been devised by Mr. Carl Dellwik, in which this fact is utilised by the adjustment of the air supply, and by keeping the level of the incandescent fuel in the generator at a constant height.

Under these conditions, the producer gas ceases to exist as a bye-product, and the products of the blow consist merely of the ordinary noncombustible products of complete combustion, carbon dioxide and nitrogen, the result being that double the quantity of water gas can be made per pound of fuel than was before possible, and the extra heat generated minimises the period of blowing, and enables runs or times of steaming to be continued far longer than has been possible before.

In the old "European" process it was necessary to blow for nearly ten minutes to bring the fuel bed up to the right temperature, whilst the period during which the incandescence was sufficiently great to decompose the whole of the volume of steam used, limited steaming to from four to five minutes, whereas in the Dellwik process the period of blowing rarely exceeds two minutes, and it is possible to steam for from seven to ten, according to the condition of the fuel.

When I first examined this process, my pre-

vious experience in water-gas making led me to believe that this procedure must inevitably form a considerable amount of carbon dioxide, but analysis soon showed that I was mistaken in this, as the crude gas collected in the holder proved, on analysis, to be of excellent quality. The following analyses of samples taken at intervals during the process of making bear this out:—

	I.	II.	III.
Hydrogen	52.43	50.09	52.76
Carbon monoxide	38.30	39.95	37.50
Carbon dioxide	4.73	5.38	4.08
Oxygen	0.74	1.22	0.46
Nitrogen	3.80	3.36	5.20

And as 5 per cent. of carbon dioxide in the unpurified gas may be looked upon as a fair average when using the old "European" process, these results are distinctly good. In order to make quite sure that no mistake was being made, analyses were taken during a series of runs, when it was found that the average came out at 4.58 per cent., the highest being 4.9 and the lowest 4.2.

In the old process, it is found that for the first two or three minutes, whilst the temperature of the fuel is very high, the reaction in the generator may be regarded as being—



but as the temperature of the fuel gets lower and lower, the action more and more nearly approaches to—



Experiments, however, show this second equation to be incorrect under the conditions existing in generators. The first product of the decomposition of the steam by the carbon is in every case carbon monoxide and hydrogen, but if the fuel is so far cooled as only to admit of the decomposition of a portion of the steam, the excess of steam oxidises the carbon monoxide into carbon dioxide, and the secret of the low carbon dioxide in the gas made by the Dellwik process, in spite of the long period of steaming, is that instead of allowing the steam to blow into the incandescent fuel in large volumes, its flow is so regulated that even at the extreme end of the run there shall be no excess of steam to oxidise the carbon monoxide to dioxide.

I made an exhaustive series of tests with this

process on an apparatus in use at Warstein, in Westphalia, and found that the completion of combustion during the period of blowing, claimed by the inventor, undoubtedly took place, as is shown by the following analyses made of the products of combustion given off during a blow. These analyses are confirmed by 13 other analyses of the carbon dioxide in the blow gas, which yielded from 18·6 to 15·1 per cent. of carbon dioxide, instead of the ordinary 5 to 6 found in the "European" producer gas.

	I.	II.
Carbon dioxide	17·9	18·8
Carbon monoxide	1·8	1·0
Nitrogen	78·6	79·5
Oxygen	1·7	0·7
	100·0	100·0

The introduction of this new process would put an entirely new complexion upon the value of water gas for fuel purposes, as only one half the weight of carbon previously employed for making the gas is now used, and instead of having only some 40 per cent. of the heat energy present in the original carbon transferred to the gas, now something like 82 per cent. of the heat value of the coke used in both generator and steam boiler is available in the gaseous condition. In other words, it is now possible to make, in the Dellwik plant, 70,000 cubic feet of water gas from a ton of good coke, whilst 34,400 was the average made by previous alternating processes.

Having now brought the history of the water-gas industry down to the present time, it is possible to look ahead and note the direction in which the recent developments in manufacture will probably influence its future.

First and foremost, it will be well to consider how far it is possible for water gas to aid the coal-gas industry in the development of light, heat, and power.

Until ten years ago, the gas manager looked askance at water gas as a possible rival, but he now freely acknowledges it to be a valuable ally, and, although the price of cannel coal has fallen again well below the figure which drove gas managers to adopt carburetted water gas as an enricher, the latter has such enormous advantages that those who have once adopted it are not likely to again abandon its use.

The great cause which has tended to check the introduction of carburetted water gas has

been the alarm felt at the poisonous properties of the carbon monoxide present in it, but the dangers due to this have been exaggerated, and whilst the introduction of carburetted water gas alone as a town supply should be absolutely vetoed, there is practically no danger in using it as an enricher when it is mixed with anything over its own volume of coal gas.

The reason for this is as follows.—Carbon monoxide is undoubtedly one of the most virulent gaseous poisons, and those who attempt to minimise the danger attending its leakage into the air of a dwelling-room are really defeating the cause they have at heart, as it is only by fully realising this fact that it becomes possible to prevent accidents which would utterly condemn its use. Pure water gas, as has been shown, contains, approximately, 40 per cent. of carbon monoxide, but this quantity is considerably reduced in carburetted water gas by the admixture of the oil gas which gives it illuminating value, and the following analyses of carburetted water gas having an illuminated value of between 22 and 23 candles, give a good idea of its composition:—

CARBURETTED WATER GAS.

	I.	II.	III.	Mean.
Hydrogen	40·22	38·37	39·72	39·44
Saturated hydrocarbons	16·80	17·12	16·72	16·88
Unsaturated hydrocarbons	8·72	8·66	7·32	8·23
Carbon monoxide	28·74	28·57	29·78	29·03
Carbon dioxide	0·00	0·00	0·00	0·00
Oxygen	0·14	0·38	0·13	0·21
Nitrogen	5·38	6·90	6·33	6·20
	100·00	100·00	100·00	100·00

From this it will be seen that the gaseous mixture contains approximately 30 per cent. of the poisonous monoxide, whilst the coal gas, if made from Durham coal as is the case in London, contains only about 4 per cent. If now a mixture of the coal gas and carburetted water gas in equal proportions were made, it would contain 17 per cent. of the monoxide, if two-thirds were coal gas, the per-centage would be 10·7, whilst one-fifth of carburetted water gas in the mixture would entail 9 per cent. of the monoxide, and it will be well to now discuss what would be the limit of safety.

The breaking of a gas main near the basement of a house and the infiltration of large volumes of gas into the house itself, the fall of a chandelier, or a serious leakage

from it when pulled too low, or the accidental cutting into a supply pipe in a wall would all give leakage of a sufficiently serious character to form a poisonous mixture, fatal in time to life whether the escaping gas were coal or carburetted water gas, and the length of time needed to bring about insensibility and finally death would probably be inversely proportional to the per-centage of carbon monoxide in the gas.

Such accidents are, however, rare, and are not the ones from which most danger is to be apprehended.

The smell of carburetted water gas being even more penetrating than that of coal gas, a leakage becomes apparent to the nose when the air contains 1 of gas to 10,000 of air, a proportion absolutely without action on health. From this it follows that it would only be during sleep that the leakage of a sufficient quantity of carburetted water gas to become dangerous to life could happen, and the leakage under these circumstances would only take place from a person going to sleep with the gas burning and some one cutting off the gas at the meter and then turning it on in the early morning, or by the more likely chance of turning off the gas-burner and accidentally turning the tap on again either through a worn stop on the tap or catching the tap in withdrawing the hand. The usual chances of leak adduced, however, are from such unlikely circumstances as the gas being blown out, an extremely difficult thing to do, or being extinguished by collection of water or naphthalene in the supply pipe, or by an irregularity in the working of the meter.

In any case, the amount of gas escaping into a room under these conditions will on an average not exceed the amount passed by an ordinary small flat-flame burner, or say, 6 cubic feet per hour.

A small bedroom will contain about 1,000 cubic feet of air space, and with the ordinary ventilating arrangements in a room of this size, and containing a fireplace, a door, and a window, the two latter being closed and no fire in the grate, the whole air in the room is probably changed twice in an hour.

The data as to the per-centage of carbon monoxide in air, which is dangerous to life, have for the most part been collected from the action of known mixtures upon rabbits and mice, and as mice are very susceptible to its action, and rabbits are very little affected by it, considerable discrepancies exist, but even if this were not so, the action of the gas on

these animals by no means necessarily indicates the action on man.

Dr. John Haldane, who has given us the only data of practical value on the effects of carbon monoxide on life, not only experimented on mice, but also tried the effect on himself, and found that 0.05 per cent. of carbon monoxide in air begins to have an appreciable effect, but can be inhaled for four hours without marked symptoms, and for all practical purposes, therefore 0.05 per cent. may be taken as the margin of safety. It will probably be urged that a larger proportion will probably do but little radical harm; indeed it is quite possible to breathe air containing 0.1 per cent. for a considerable period without danger, but it must be remembered that both coal gas and carburetted water gas contain hydrocarbons, the toxic action of which are but little known, and when the action of these bodies is taken in conjunction with the effect of the carbon monoxide, the limit fixed seems a reasonable one.

If gas escapes into a room having a capacity of 1,000 cubic feet, at the rate of 6 cubic feet per hour, whilst the air of the room is changed twice in the hour, then, after 3 to 4 hours, the per-centage of gas will rise to 0.3 per cent., and the rate of leakage and of removal by the changing of the air will become constant, and the per-centage of gas will not rise above that point however long the leakage may continue.

It has been shown that .05 of carbon monoxide may be inhaled for 4 hours without dangerous symptoms, and this amount of carbon monoxide will be present if it constitutes one-sixth or 16.6 per cent. of the mixture.

Approximately, this composition is arrived at with a mixture of one-half coal gas and one-half carburetted water gas, and it should be clearly understood that this proportion should not be exceeded.

The figures are given for coal gas of the quality and composition of that made in London, but it must be remembered that the carbon monoxide in the coal gas varies with the oxygen present in the coal carbonised, and although London gas made from Durham coal only contains from 3 to 4 per cent. of this gaseous bugbear, Edinburgh gas contains an initial per-centage amounting to from 10 to 11 per cent., and the amount of carburetted water gas which can with safety be mixed with the town supply, will vary with the local factors of composition, and the mixture sent out must be so regulated that the carbon monoxide shall not exceed a maximum of 16 per cent.

In such a calculation the weak point is,

of course, the rate at which the air in the room is changed, which will vary greatly with differences in atmospheric conditions, but the presence of a living being in the room will always tend to raise the temperature in the room, and so promote change with the external air.

Moreover, the density of the gaseous mixture being only one-half that of the air, it is probable that for a considerable period the air nearest the ceiling would contain most of the gas, and that it would take some time for the mixture to become equal throughout the room.

The question arises, is carburetted water gas an accumulative poison, *i.e.*, can it be inhaled in small quantities, and be retained in the system day by day until health is undermined?

In the continuous breathing of small percentages of carbon monoxide this might be the case, but if there is any change of locale it would be practically impossible. A person sleeping in a room with a leaky gas-fitting might each night take into his system a small trace of the gas, but in his out-door life in the day-time this trace would be eliminated, so that unless confined to one apartment for a very long period no such action would be likely to happen. In my experience, men exposed to this gas in working producers, &c., soon get used to its effects and show no loss in health.

In most of London north of the Thames, including the City, the per-centage of carbon monoxide in the gas supply has varied during the past few years from 7 to 10 per cent., and once it was found as high as 12, but the following tests taken lately give a fair idea of the average present—

Date 1898.	Per-centage of Carbon Monoxide.
February 14	8.82
„ 21	7.77
March 24	8.57
„ 28	7.94
„ 30	8.40
„ 31	8.33
April 13	8.59
„ 21	7.47
„ 28	9.03
„ 29	7.75

And when it is considered that this is below the quantity present in many pure coal gas supplies distributed in the North of England, it is at once evident that there is nothing to take exception to in the London supply, and there

is no doubt but that in the future the use of carburetted water gas as an auxiliary to coal gas will become universal in works of sufficient size to make its manufacture economical.

An even greater development will, however, probably be found during the next ten years in the use of pure water gas for outdoor illumination by means of incandescent mantles, and for the generation of power by means of suitable gas motors.

The successful introduction of water gas for these purposes entirely depends upon the cost of production, and whereas under the European system the water gas cost from 4d. to 6d. a thousand, according to the size of the installation and the price of fuel, the price could now be reduced, on a large installation of the Dellwik plant, to below 3d., the items of cost being approximately as follows:—

	Pence per 1,000 cubic feet.
Coke at 9s. per ton.....	1.50
Gas maker	.23
Engine driver and boiler man....	.23
Coke man	.17
Purifying	.15
Wear and tear	.10
Interest	.20
Water.....	.10
Oil, waste, &c.....	.07
	2.75

These figures could, of course, only be obtained in constant working, and on a large scale, but, for the sake of comparison, we will take water gas in the holder as having cost 3d. per 1,000, whilst coal gas under the same conditions would cost 1s. to 1s. 3d.

When attempts were first made to introduce water gas for illuminating purposes, it was used in conjunction with the Fahnjelm magnesia comb, which gives a light of 4.5 candles per cubic feet of gas consumed, this duty, however, falling as the comb gradually burns away, its average life being not much over 100 hours.

Great as was the gain when used in this way over the light obtainable from a flat-flame burner with coal gas, it has been entirely eclipsed by the brilliancy of the modern incandescent mantle.

For use with this, the water gas has to be freed from the gaseous compound of carbon monoxide and iron, which it nearly always contains, and which, during combustion, would deposit oxide of iron on the mantle and quickly reduce its light-giving power.

The combustion of water gas only develops half the thermal value that is to be obtained from an equal volume of coal gas, and many theorists imagine from this that its power of developing light from a mantle would be less in the same ratio. This, however, is an error, as the gas being non-luminous, is burnt at a burner of the Argand type without previous admixture with air, and giving a very intense combustion on the surface of the mantle where the gas and air meet, develops a higher illuminating value than could be got from coal gas in an atmospheric burner. The mantles used for water gas on the Continent are made of the Auer mixture of 99 per cent. thoria and 1 per cent. ceria, but the mesh is larger and thicker than with the ordinary mantle, and with a consumption of 7 cubic feet of water gas at eight-tenths pressure, I have obtained 137 candles illumination, or 19·8 candles per foot, and for lighting streets, squares, or large buildings, water gas could be perfectly well used, and would give the light at a price impossible to equal by any other means.

An even larger field, however, is to be found in the development of power by water-gas engines.

The gas-engine is hardly perfected for coal gas and wants several alterations before it is properly adjusted for water gas, yet with all its imperfections a consumption of 44 cubic feet gives a brake horse-power per hour, or a cost of 0·12d. per brake horse-power, and this is being rapidly improved on, and Messrs. Crossley state that the engines now made would use nearly 40 per cent. less gas for the same result.

If this be so, the importance of water gas for the development of electric power, either for lighting or for the manufacture of calcic carbide, aluminium, &c., at once becomes manifest, as the cost of production would be only one-fourth of that entailed by the use of steam power, and if the installations were at the gas works and the red-hot coke run direct from the retorts to the generators, a still greater saving could be effected. Where Corporations have the control both of the gas works and also the electric lighting of a town, the generation of current by means of water gas generated from their coke by means of a Dellwik plant, would not only give electrical power at a price far below that at which it is obtainable by other means, but would also keep up the price of the coke. These are two only of the many applications for which the cheapened water gas would be available,

whilst in metallurgy, glass making, and for kiln firing, an endless field should be open, and we shall yet see water gas purged of its past offences and playing an important part in the march of civilisation.

DISCUSSION.

The CHAIRMAN said the paper, as usual with Professor Lewes, contained much that was new, but to him the most interesting part of it was that which dealt with the more or less dangerous character of the gas, on account of the per-centage of carbon monoxide it contained. It occurred to him that after all gas was made to burn and not to breathe, and if the sense that there was greater danger about inhaling carburetted water gas led consumers to pay more attention to their fittings and so prevent leakages, that would be an advantage, whether they continued to use water gas or returned to coal gas only. While in the United States he made every inquiry amongst his friends, many of whom were at that time strongly opposed to the new gas, as to what had been the effect in towns where water gas was used either exclusively or partially, and he was assured by every one that so far as they had been able to ascertain there was not one case in which it could be said that poisoning or suffocation had taken place because of the presence of a greater or less per-centage of carbon monoxide, but that where there had been any fatal result, it would have happened equally, whether the gas had been ordinary coal gas, carburetted water gas, or a mixture of the two. Professor Lewes had given an interesting calculation as to the per-centage of carbon monoxide, which would be accumulated in a room of a certain size, assuming the gas to continue to escape for an indefinite period. It was rather a small room, and if it had been larger, of course the per-centage would have been less, but he felt quite sure that if anyone went to sleep in a room, with a gas burner delivering 6 cubic feet per hour of gas made by any gas company in the kingdom, without any water gas in it at all, the condition in which he woke in the morning—if he woke at all—would be a very uncomfortable one. The question of escapes was so small a one, that it weighed, in his opinion, very little in comparison with the undoubted fact that the sanitary results of burning carburetted water gas was less objectionable than the burning of ordinary coal gas; the proportion of sulphur compounds remaining in the gas was very much less, the quantity of atmospheric oxygen required to support the flame much smaller, and consequently the generation of carbonic acid gas was less. If then the results of the legitimate application of the gas were distinctly to the advantage of the consumer, he thought they might, with equanimity, face a certain

amount of additional risk from inhaling gas escaping in such a manner as had been suggested.

Mr. CHARLES GANDON said he had had no practical experience of water gas, but there were one or two questions he should like to put to Professor Lewes. He had referred to the producer gas formed being used to heat the chambers for the decomposition of the oil, but he understood that in the Dellwik generator carbonic acid was principally produced, not carbon monoxide, and he should like to know whether that was equally available for the superheaters. He was also at a loss to understand how that generator was able to run so much longer without being blown up with air than the other ones where there was so much deeper body of fuel. One would think a deeper bed of incandescent material would last longer than a shallow one. He entirely agreed that the bugbear of increased danger from the use of water gas came to nothing when the matter was properly considered.

Mr. J. J. SMITH asked if the products of consumption in the case of water gas were similar to those from coal gas, or if a higher per-centage of carbon monoxide was formed. As he understood, in blowing up the furnace carbon monoxide was formed as a waste product: could not that be utilised by burning it into carbonic acid?

Professor LEWES, in reply, said Mr. Gandon had raised a point of considerable practical interest. He asked why it was if in the old-fashioned method of generating by blowing up so as to get producer gas, you utilised that producer gas straight off, and so made it into a perfect heat-engine, and the Dellwik generator gave off no producer gas, but merely the ordinary products of combustion, the latter could come in as a competitor in carburetted water-gas processes. In this country it would only come in on rare occasions as a competitor, but on the Continent, the Dellwik process had the biggest future of any generator for making carburetted water gas. There, water gas as it is made in this country and in America, was practically an impossibility, because in Germany, France, and Belgium, the price of oil, owing to duties and other factors, was so high that it was impossible to make carburetted water gas to compete with coal gas, by the improved Lowe process of cracking up the oil in superheated chambers so as to get oil gas from it. What had to be done there was to make pure water gas and carburet that by the products which the gas manager had at his disposal. Extended experiments made by Bunte and other, showed that benzole was the most valuable enricher, and that was used by systems much akin to the Maxwell-Clerk type for enrichment on the Continent, and he heard within the last fortnight two of the biggest towns in Germany were adding to their gas supply in that way, large installations on the Dellwik principle being erected

at Konigsberg and Posen. They made it by the Dellwik generator, in the proportion of about one-third of the consumption, and having mixed it with the ordinary coal gas they passed the mixture through benzole enrichers and it formed an excellent illuminating gas. Therein lay the difference between that which was possible in England, and that which was possible where they do not get cheap oil. The Dellwik process was therefore of enormous value to them. Here it had very small value for such purposes; it would only have a future if our oil supply were interfered with. It was for incandescent mantles in open spaces, for motive power, for obtaining electricity, and for manufacturing purposes, such as glass-making, enamel-making, and things of that kind, that it really would have a future. In making glass, fuel gas made by practically the Siemens process was used, and in certain parts of the process, where they required a sharp heat to get the glass as liquid as possible in order to get a rapid clearing of the little bubbles which were formed in it, water gas would enable them to govern the heat much more perfectly than at present. It would also be useful in steel-making and other operations, but not for making carburetted water gas. With regard to the fuel in the Dellwik generator, it was kept constant by the slip of coke in the inclined retorts, and by using a big air supply which was fairly evenly distributed over the fuel. It was thus heated up to a very high temperature, owing to the combustion of the carbon monoxide in the fuel itself, and all the heat was left in the one chamber. Then the steam was admitted at a carefully regulated rate, which would not give an excess of steam for oxidising the already formed carbon monoxide. It was by this regulation of the air and steam that the success of the apparatus was secured. With regard to the products of combustion, water gas, pure and simple, consisted of carbon monoxide and hydrogen in practically equal proportions, with a few impurities, and when burned the carbon monoxide was converted into carbon dioxide, and hydrogen into water vapour. Complete combustion in a proper burner gave practically no carbon monoxide when used in a mixture with coal gas for incandescent mantles or gas flames, there was practically no variation in the products of combustion. Such a mixture was better fitted for use with incandescent mantles than coal gas alone, as it required a slightly lower proportion of air for complete combustion, and there was less liability to blackening the mantle. With regard to the producer gas being a waste product, he had pointed out that it had to be blown away owing to its only being formed intermittently, and also because the amount of combustible matter in it was so low that it would not pay for storing. In some cases it had been used successfully, and there the old process was a success. He had seen installations in which the water gas was made in large quantities, and the producer gas being of course four times the quantity, a certain proportion was used for firing the boilers; by having a number of generators

one would be blowing while the other was steaming, and so they were able to get a fairly constant flow. Under these conditions you could use it, mixed with water gas, for making Siemens-Martin steel, and could also utilise it in burning in big tubular boilers, and then it became worth making. It was that loss of the producer gas, which was a necessity in small works, which had led to the failure of water gas made by the old process, and that objection was removed by the Dellwik process, which would make a success for pure water gas, much as the success of the carburetted water gas had been attained by the introduction of the carburetting process.

Mr. RICHARDSON said, if it was not too late, he should like to know the relative explosive properties of coal gas, water gas, and water gas as enriched on the Continent with benzole.

Professor LEWES said the effect of an explosion with the ordinary mixture would be as nearly as possible the same as with coal gas; with pure water gas it would be considerably less. In all probability the explosive power would be rather greater with water gas carburetted with benzole, as was done in Germany, than with carburetted water gas made by perfect cracking of oil.

The CHAIRMAN, in proposing a vote of thanks to Professor Lewes, said few men possessed so fully the faculty of making not only clear but interesting, what in some hands would be a dull subject. He might say that in spite of the effect of duties, and so forth, which caused mineral oil to be very dear on the Continent, the process which had been described was already in use in Germany, Belgium, Holland, and Denmark, and its extension in Germany was simply a question of time, because there was, fortunately, a fair supply of shale and other oils which would be free from duty.

The vote of thanks was carried unanimously, and the meeting adjourned.

Miscellaneous.

THE "GOTHENBURG SYSTEM" AND THE SALE OF SPIRITS IN SWEDEN.

The scheme for regulating the sale of spirits, which originated at Marstrand, but which is commonly known as the "Gothenburg system," began about 1865 in Gothenburg, and in 1877 in Stockholm. The theory of the Gothenburg system is the transference by the local authorities of the public house licenses to a company, who after taking 6 per cent. as interest on the capital invested, and after payment of the expenses

of management, hand over the balance of profit to the city or communal authorities. It must be borne in mind that the Gothenburg system only affects the sale of spirits and not beer, which according to Mr. Arthur Herbert, Secretary of H.M. Legation at Stockholm, is very good in Sweden but of low alcoholic strength. The keynote of the whole system is that neither shareholders nor persons engaged as managers should derive any profit from sale beyond a fixed percentage on the capital invested. The company bought up the public house licenses, granting in return fixed annuities to the owners, but the licenses were not those of "tied" houses, which would make it much easier to hold out, and thus artificially force up the price of the license. This involved in Stockholm the annual payment of about £7,000 as annuities. The first use the company made of their monopoly in Stockholm was at once to reduce the number of public houses by half, and the sanitary and general condition of the others was greatly improved. These improved conditions, it is considered, have contributed as much as anything else to the decrease of drunkenness. In England it is argued that the existence of a "bar" where the customer cannot sit down is the best artificial check to drunkenness, but in Sweden, on the other hand, it is thought that in well ordered and respectably-frequented premises, where the manager has no interest in the sale of spirits, is to be found the best safeguard against excess. Moreover, the wording of the contract states "that the manager is bound to supply his customers with good and well-prepared food, cold or warm, and he is on his own account to carry on the sale of provisions as well as wine, coffee, tea, cocoa, soda, and seltzer waters, &c., as would be done in a well conducted eating-house." The proof that the system pays from a monetary standpoint, and is efficient in checking drunkenness, is at once seen by the fact that it is in operation all over Sweden, and that the Governors appear to have borne unvarying testimony to its beneficial effects. The public-houses are closed at 10 p.m., and at 6 p.m. on Saturday evenings, and on Sundays and holidays no spirits are served unless food is taken at the same time.

COTTON INDUSTRY IN THE UNITED STATES.

The continued growth of the cotton manufacturing industry in the States of South Carolina, North Carolina, and Georgia continues to attract the attention of those interested in that business, and some interesting figures are given in the last report of Consul de Coëtlogon of Charleston. South Carolina is now operating more spindles than any of the other Southern States, North Carolina being second, and Georgia third on the list. At the end of 1897, South Carolina had in operation 54 cotton mills with nearly 1,000,000 spindles, and consuming annually

148,767,042 lbs. of cotton, equal to about 327,000 bales or, say, 40 per cent. of the total crop produced in the State during the year, estimating the same at 800,000 bales in round numbers. North Carolina had 150 mills; the total number of spindles however was smaller, but will probably reach 1,000,000 also, when mills now being built are completed. Roughly speaking, therefore, it may be said that the two Carolinas had, at the end of 1897, each about 1,000,000 spindles and 25,000 looms in actual operation manufacturing cotton goods. The relative growth and importance of the industry is apparent, from the fact that the total number of cotton mills in the Southern States amounts to 375, with 3,197,000 spindles, and manufacturing 500,000,000 pounds of raw cotton annually. This shows that the Carolinas have nearly double the number of mills and spindles of all the other States in the South combined, and consuming about three-fifths of the yearly quantity of raw cotton taken by Southern mills. Georgia, which is by far the most important of the other Southern States manufacturing cotton, after the Carolinas, has a number of splendidly-equipped mills and abundant water power at Augusta and Columbus, and in that State are situated most of the cotton mills and spindles not above enumerated in the figures given for the Carolinas; the three States combined practically embracing the principal cotton-manufacturing industries of the South. In addition to the foregoing cotton mills there are also at present in North Carolina the following other textile manufacturing establishments, namely, 16 woollen mills with 5,038 spindles, and 234 looms, 25 cotton hosiery mills, with 1,410 knitting machines, 4 bleacheries, and 4 dyeing and finishing mills, but there are no woollen mills as yet in South Carolina.

ITALIAN CHEESE.

The cheese which is chiefly produced in Italy is the "grana" (or Parmesan cheese), so called from its granulated texture, next comes the "gorgonzola," "emmental" and "stracchino" of Lombardy, the "fontina" of the valley of Aosta, and the "cacio cavallo" of Rome and southern Italy. The latter is, however, produced on a small scale also in Lombardy. In shape, grana cheeses are round, have an average depth of 8 inches and a diameter of 2 feet. Those produced at Parma, Reggio, Emilia and Modena weigh from 44 to 132 lbs., with an average of 79 lbs. In Lombardy the cheeses weigh from 110 lbs. to 155 lbs., and even 200 lbs. Grana cheese cannot be exposed to a high temperature without injury, yet it stands long journeys if properly packed. Consul-General Chapman, in a report on the dairy industry of Italy, states that the whey that remains after the cheese is made is generally utilised in Italy to make the "ricotta," which is produced in the following manner. The whey is heated up to 80° Centigrade (176° Fahrenheit) and worked up with the "follatoio," a

long stick, to the end of which a round wooden disc is affixed. In less than an hour the "ricotta" appears on the surface of the liquid, and is collected and placed in baskets to dry. The ricotta is either eaten fresh, or else is salted and dried in the oven, when it is used by the peasantry as cheese. The principal centres of production are the provinces of Milan (Milan, Lodi, Codogno), Como (Lecco), Pavia, Reggio, Emilia, Parma, Belluno, Modena, in the north of Italy, where abundant pasture for the feeding of cattle is always available.

AERIAL CABLE SERVICE IN VENEZUELA.

The United States Consul at Maracaibo, writing under date of the 6th January last, reports that the Venezuelan Minister of Public Works and Dr. Jorge Valbuena have entered into a contract for the construction of an aerial steel cable service for the transportation of merchandise, timber, animals, &c. One cable from a point in the valley of Tovar, section Merida, State of Los Andes, to the point of Escalante River, and another from the city of Merida, or from any other point of that section, to one of the ports of the district of Sucre, on Lake Maracaibo, State of Zulia, or to Santa Barbara, on the Escalante, for the safe and rapid service by cable, and responsibility for goods and valuables transported thereon. Government mails will be transported free, and Government freight and postal packages at 50 per cent. of the ordinary rates charged to the public. Freight tariffs are to be fixed by the contractor and the Government. Work must begin within one year after congressional approval of the contract, and twenty kilometres (12·4 miles) at least must be completed per annum. The service is exempt from all national taxation. The contractor can employ whatever motive power he chooses, and can establish for the sole use of the service telegraph and telephone lines between the points traversed by the cables. The duration of the contract is fifty years, at the expiration of which period the works become the property of the Government. By consent of the Government, the contract may be transferred to a foreign company.

THE CORAL INDUSTRY OF NAPLES.

The plague and famine in India have had a disastrous effect on the coral trade, which was already suffering from the dictates of fashion. The markets of Calcutta and Bombay have been practically closed, the natives being rather sellers than buyers of personal ornaments. Consul Neville Rolfe, of Naples, says that in hopes of giving a new impetus to the industry, the school of coral work at Torre del Greco has been endeavouring, and with distinguished success, to effect a new departure in the art, in order that the workmen of the town may still find employ-

ment in their hereditary industry. They have caused instruction in mosaic work to be given, and mosaics in charming patterns have been made of combinations of coral, tortoiseshell, mother-of-pearl, and metals such as are used for the purpose in similar industries. The articles chiefly made hitherto have been such things as ornamental frames for portraits, glove boxes, and the like, and the work has been adopted for the decoration of mandolines, guitars, and other musical instruments. It is hoped to introduce its use for the decoration of articles of furniture, such as tables and bookcases, and to combine it with the rose-pink shell and the cameo shell, both of which are fairly abundant, and therefore not excessively costly. Red coral is a gift of the Mediterranean, and is found nowhere else. It consists chemically of pure carbonate of lime (chalk), and, owing to its varying shades, is chiefly used for ornamental purposes. On account of its hardness it takes a high polish, white and black. Black corals are also found in the Mediterranean, and, like the red, is used for decorative purposes. Coral is worked up for the market by grinding it with emery and oil, and obtains a high polish by means of steel. Beads are turned on a lathe.

General Notes.

THE LEATHER INDUSTRY IN GERMANY.—Some interesting particulars are given in the *Moniteur Officiel de Commerce* respecting the leather trade of Germany. The leather industry is one of the most important of the Empire, occupying the third or fourth place, and is growing steadily. In 1895, 596,717 persons were employed, 433,586 of this number were occupied in making shoes, 74,839 in saddlery, harness, &c., 47,480 in tanning, and 16,278 in glove making. In the same year skins were imported to the value of £7,000,000 (in round numbers), and exported to the value of £2,400,000. Over £1,400,000 worth of materials for tanning were imported. Exports of prepared skins and leather amounted to nearly £5,000,000, and manufactured leather was exported to a very large amount. Hamburg has become the market of the Continent for skins and tanning material, Havre and Antwerp having been entirely eclipsed in that line. The German army uses an immense number of leather articles. Half a million pairs of shoes are furnished to the army during the year, not to speak of repairs, new soles, &c. There is every prospect that the industry will still further develop, since it is yet only in the period of transition between the primitive methods of hand labour and mechanical production. Special schools and technical institutions have been established in different cities of Germany where

tanning, glove cutting, and sewing, shoe and harness making, and other branches of the leather trade, are taught.

RECEIPTS OF PARIS THEATRES IN 1897.—An interesting return has just been issued by the Director of the General Administration of Public Assistance in France, showing the gross receipts of the principal places of amusement in Paris during each of the years 1850 to 1897 inclusive. During this period the largest amount realised in any one year was in 1889, the exhibition year, when the receipts amounted to £1,292,760; the nearest approach to this was in 1897, when they reached £1,229,680. In 1878, also an exhibition year, the amount realised was £1,226,296, and the lowest amount realised in any one year was, as may be imagined, in 1871, when only £228,000 were received. Taking the amounts received at each establishment last year, it will be found that the Opera, as usual, heads the list with a revenue of £126,672, then comes the Comédie Française with £84,168, and the Opera Comique with £58,404. The Folies Bergère realised £54,112; the Vaudeville, £45,696; the Renaissance, £40,692; the Châtelet, £40,328; the Variétés, £39,660; the Gaité, £34,628; the Scala, £34,236; Gymnase, £31,362; Nouveautés, £29,056; Folies Dramatiques, £27,660; Ambiga, £27,048; and Olympia, £26,060. The Conservatoire concerts realised £6,724; the Colonne concerts £9,808, and the Lamoureux concerts £4,340.

OYSTER CULTIVATION AT ARCACHON.—A leading branch of industry of the Bordeaux district is that of oyster cultivation. The basin of Arcachon is the cradle of the bivalves where they are reared and despatched, either for immediate consumption or for education of an inverse kind, as the French taste is for green oysters, and the young oysters are sent in millions to Marennes, in the department of the Charente Inférieure, to become green. According to Consul Hearn, in that district the oyster-beds are covered with a delicate green weed of a perfectly wholesome and harmless nature, the scientific name of which is *Navicula ostrearia*, and on which the oyster rapidly fattens, its beard acquiring a dark green hue, and the bivalve itself an exquisite flavour. Oysters are exported in large quantities by parcel-post to private persons, and in larger quantities to wholesale dealers. The price of Arcachon oysters of three years' growth is about 4 francs (3s. 2d.) per 100, while very fine fat "Marennes" green oysters sell retail for 8 francs (6s. 4d.) to 12 francs (9s. 6d.) the 100. The annual production of Arcachon oysters laid down and bred amounts to between 500,000,000 and 600,000,000. The number of oysters sent annually to French oyster-growing places varies from 120,000,000 to 130,000,000, leaving some 450,000,000 for export and local consumption.

MEETINGS OF THE SOCIETY.

ORDINARY MEETINGS.

Wednesday Evenings, at 8 o'clock:—

MAY 18.—“The Evolution of the Cycle.” By J. K. STARLEY. C. V. BOYS, F.R.S., will preside.

INDIAN SECTION.

Thursday Afternoons, at 4.30 o'clock:—

MAY 19.—“Chartered Companies and Colonisation.” By Sir ALFRED COMYNS LYALL, G.C.I.E., K.C.B., D.C.L. (Member of the Council of India). HENRY M. STANLEY, M.P., will preside.

FOREIGN AND COLONIAL SECTION.

Tuesday afternoon, at 4.30 o'clock:—

MAY 24.—“The Goldfields of British Columbia.” By W. HAMILTON MERRITT. Sir CHARLES MALCOLM KENNEDY, K.C.M.G., C.B., will preside.

CANTOR LECTURES.

Monday Evenings, at Eight o'clock:—

PROF. CHARLES A. CARUS WILSON, M.A., M.Inst.E.E., Professor of Electrical Engineering, McGill University, Montreal. “Electric Traction.” Four Lectures.

LECTURE III.—MAY 16.

Energy diagrams—Sub-divisions of energy expenditure—Case when final speed is fixed—Possible ways of reducing the expenditure—Effect of series winding is to reduce the heat loss—Highest economy limited by the weight of the motor—How to find the best values of gear-ratio and driving-wheel diameter—Example—The Baltimore and Ohio Railroad—Effect of reduction in train resistance—Use of roller bearings.

LECTURE IV.—MAY 23.

Case when the final speed is not given—Design for covering a given distance in the shortest time for a given current—Time curves—Effect of using driving-wheels of different diameters—Design for covering a given distance in a given time, with the least possible expenditure of energy—Influence of the weight of the motor on the economy—Advantage of gearing—Example—The Chicago Metropolitan Elevated Railroad.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 16... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. Carus Wilson, “Electric Traction.” (Lecture III.) Surveyors, Savoy-street, W.C., 8 p.m. Mr. H. T. Eve, “Compensation Values of Cattle Foods—Chemist *versus* Valuer.” British Architects, 9, Conduit-street, W., 8 p.m. Mr. T. G. Jackson, “The Libraries of the Middle Ages.” Medical, 11, Chandos-street, W., 8½ p.m. Annual Oration. Victoria Institute, 8, Adelphi-terrace, W.C., 4½ p.m. Dr. Schofield, “The Philosophy of Education.”

TUESDAY, MAY 17... Royal Institution, Albemarle-street, W., 3 p.m. Dr. S. R. Gardiner, “The Historical Development of Modern Europe.” (Lecture III.) Statistical, in the Theatre of the United Service Institution, Whitehall, S.W., 5 p.m. Mr. G. Laurence Gomme, “Local Taxation in London.” Pathological, 20, Hanover-square, W., 8½ p.m. Annual Meeting.

Photographic, 12, Hanover-square, W., 8 p.m. Zoological, 3, Hanover-square, W., 8½ p.m. 1. Mr. Oldfield Thomas, “A small Collection of Mammals obtained by Mr. Alfred Sharpe in Nyasaland.” 2. Dr. A. G. Butler, “Collection of Lepidoptera made in British East Africa by Mr. C. S. Betton.” 3. Miss Sophie M. Fedarb, “Some Earthworms from India.”

WEDNESDAY, MAY 18... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Mr. J. K. Starley, “The Evolution of the Cycle.”

Meteorological (in the Rooms of the Astronomical Society), Burlington-house, W., 4½ p.m. 1. Mr. Robert H. Scott, “The Frequency of Rainy Days in the British Isles.” 2. Frederick J. Brodie, “The Abnormal Weather of January, 1898.”

Geological, Burlington-house, W., 8 p.m. Microscopical, 20, Hanover-square, W., 7½ p.m. Exhibition of Microscopic Aquatic Life.

United Service Institution, Whitehall, S.W., 3 p.m. Dr. J. Macdonell, “Recent Changes in the Rights and Duties of Belligerents and Neutrals according to International Law.”

Archæological Association, 32, Sackville-street, W., 4½ p.m.

Pharmaceutical, 17, Bloomsbury-square, W.C., 8 p.m. Annual Meeting.

THURSDAY, MAY 19... SOCIETY OF ARTS, John-street, Adelphi, W.C., 4½ p.m. (Indian Section.) Sir Alfred Comyns Lyall, “Chartered Companies and Colonisation.”

Chemical, Burlington-house, W., 8 p.m. 1. Mr. G. T. Morgan, “The Action of Formaldehyde on Amines of the Naphthalene Series.” 2. Mr. F. G. Ehmed, “The Constitution of Oleic Acids, and its Derivatives.” (Part I.)

Society for the Encouragement of Fine Arts, 9, Conduit-street, W., 8 p.m. Dr. J. S. Phené, “Pre-Roman Gold Work and Magnificent Pre-Roman Jewellery manufactured in the British Isles in Pre-Historic Times.”

Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, “Heat.” (Lecture II.)

Historical, 28, Jermyn-street, S.W., 8½ p.m.

Numismatic, 22, Albemarle-street, W., 7 p.m.

FRIDAY, MAY 20... Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Right Hon. Dr. Madden, “The Early Life and Work of Shakespeare.”

Quekett Microscopical Club, 20, Hanover-square, W.C., 8 p.m.

SATURDAY, MAY 21... Botanic, Inner Circle, Regent's-park, N.W., 3½ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Mr. J. A. Thomson, “The Biology of Spring.” (Lecture I.)

CORRECTION.—Sir George Birdwood wishes to make the following corrections in his letter on “Ancient and Modern Ink.” Page 567, col. 1, line 4 from bottom, *for* “xxiv.” *read* “xxxiv.”; line 3 from bottom, *for* “sulphate,” *read* “acetate”; col. 2, line 12 from top, *add* after “removed,” the words, “confirm this view.”

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FRIDAY, MAY 20, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.

CONVERSAZIONE..

The Society's *Conversazione* will take place at the Natural History Museum, Cromwell-road, S.W. (by permission of the Trustees of the British Museum), on Wednesday, 22nd June. The reception will commence at 9 p.m.

The following portions of the Museum will be open:—On the Ground Floor—the Central Hall, British Saloon, and Bird Gallery; on the First Floor—the East and West Corridors, and the Lecture Room.

Each member is entitled to a card for himself (which will not be transferable), and a card for a lady. In addition to this, a limited number of tickets will be sold to members of the Society, or to persons introduced by a member, at the price of 5s. each, if purchased before the date of the *Conversazione*. On that day the price will be raised to 7s. 6d.

These tickets will only be supplied to persons presenting members' vouchers (which can be obtained from the Secretary) or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman.

Light refreshments (tea, coffee, ices, claret cup, &c.) will be supplied.

Visitors arriving or leaving by either of the Metropolitan Railways will be allowed the use of the District Company's Subway, which leads from the South Kensington Railway Station direct into the grounds of the Museum.

CANTOR LECTURES.

On Monday evening, the 16th instant, Prof. CHARLES A. CARUS WILSON, M.A., M.Inst.E.E., delivered the third lecture of his course on "Electric Traction."

The lectures will be printed in the *Journal* during the summer recess.

INDIAN SECTION.

Thursday afternoon, May 19; HENRY M. STANLEY, M.P., in the chair. The paper read was "Chartered Companies and Colonisation," by Sir ALFRED COMYNS LYALL, G.C.I.E., K.C.B., D.C.L., Member of the Council of India.

The paper and report of the discussion will be published in a future number of the *Journal*.

Proceedings of the Society.

REPORT OF THE COMMITTEE ON THE DETERIORATION OF PAPER.*

Committee.—Sir John Evans, K.C.B., F.R.S. (Chairman); Maj.-General Sir Owen Tudor Burne, G.C.I.E., K.C.S.I. (Chairman of the Council); Sir William Anderson, K.C.B., D.C.L., F.R.S.; Michael Carteighe; George Clulow; C. F. Cross, F.C.S.; Richard Garnett, C.B., LL.D.; Hugo Müller, Ph.D., F.R.S.; William J. Russell, Ph.D., F.R.S.; Henry R. Tedder, F.S.A.; William Luson Thomas, R.I.; Professor J. Millar Thompson, F.R.S.; Dr. Quirin Wirtz, M.A., F.I.C.; Sir Henry Trueman Wood (Secretary).

During the present century the paper-making industry has undergone many revolutionary changes. As an industry it has grown prodigiously, and to meet the requirements of the enormously increased production a quantity of new fibrous raw materials have been introduced and have taken their place in due course as indispensable staples. The more important of these, so far as concerns this country, may be noted in chronological order, thus: esparto, in the period 1860-70; "mechanical wood" or ground wood pulp, in 1870-80; the wood celluloses, in the period 1880-90. These substances differ in chemical composition from the celluloses obtained from cotton, flax and hemp, which were the exclusive staple raw materials for paper making up to this century; and although they are efficient substitutes in most respects, it must be admitted that Time

* This report will be reprinted with an appendix containing abstracts of papers on the testing of paper in Germany.

has not yet been able to pronounce a judgment upon the relative permanence of the papers made from them. There is more than a suspicion that many of them are very inferior in this important respect, and it has been the main purpose of the work of the committee to sift the evidence upon which such suspicions have been engendered.

Paper-making as an *art*—both mechanical and chemical—has advanced in similar measure, and although a sheet of paper made to-day necessarily differs but little as a fabric from the papers of previous epochs, the auxiliary methods of treating the vegetable fibres up to the point of putting them together as a sheet of paper have been much extended and developed. It would be difficult in fact to imagine more perfect adjustments of means to the one end than those which have been evolved to meet the modern demand for paper in all its varieties.

The science of the art has advanced also; but not *pari passu*. The production of paper and its applications rest rather upon conventional adjustments than upon such principles as may properly be termed scientific. It is not to be objected to this statement that the industry gets on very well without conforming to such a view. On the other hand, there is no need to take the statement as implying any wholesale criticism of paper-making methods as unscientific.

What is intended in and by the statement will be more exactly appreciated from what follows in explanation of the main subject to which the committee were asked to give their attention, that is the question of *standards of quality of papers*.

Paper being a fabric or structure, its qualities as such admit of more or less precise definition under such heads as—

Strength, expressed in terms of the weight or strain which it will support.

Elasticity and Texture, measured by elongation under strain and resistance to rubbing.

Bulk, expressed in the precise terms of specific gravity or weight per unit of volume.

Of not less importance than physical qualities are those which belong to paper as a chemical substance (or mixture), these are (1), its actual composition; (2), the liability to change under whatever conditions of storage and use to which it may be subjected. Living in this age, it is impossible to resist the

tendency to take these physical and chemical constants of paper into account in specific terms. Such constants have the inevitable force of scientific quantities; they must come more and more into practical consideration, and ultimately to rank as regulating the consumption, and, therefore, production of papers.

This conviction the Committee feel themselves bound to record. The forecast rests upon no prophetic insight but upon the knowledge of what has been accomplished in this direction in continental countries, and notably in Germany. Through the investigations of the Imperial Testing Institution of Berlin a scheme of testing of papers has been formulated and officially adopted, by which the chemical and physical properties of papers are brought to numerical expression. A more obviously important result is that standards of composition have been promulgated by the Institution, and being officially adopted by the Government, have exercised an important influence upon the paper trade of Germany. Other Governments have followed the lead of Germany in this matter. The Committee recognising this advance have felt that they would render a service to the technical public of this country by reproducing in abstract form the whole of the official publications (reports) of the German Imperial Testing Station, so far as relates to the subject of paper. The work of abstracting these "*Mittheilungen der K. K. Versuchs Anstalt*" has been ably carried out by Mr. Kershaw under the direction of the Committee, and will form an Appendix to this report.

It is not suggested that the standards arrived at by these investigations and adopted by the German Government will come to be recognised as regulating the English paper trade. They form an important contribution to the science of the subject and are reproduced for this their special significance. The matter must be left to adjust itself on the basis of public opinion. The Committee cannot do more than offer this contribution of material necessarily to be taken into account by the English technical public.

The more practical work of the Committee has been to formulate positive conclusions upon a subject which is perhaps only a side issue of the wider question of paper standards, viz., the question of the "*Deterioration of Papers*." This matter is in a somewhat nebulous position: on the one hand it is well known that papers have come down to us from the Middle Ages in a perfect condition of pre-

servation; on the other there are many instances of the total destruction of books produced within quite recent years. There are not wanting those who are so influenced by this superficial antithesis, as to generalise it into a condemnation of present day papers, as compared with those of the olden times. Between this excess of zeal on the one hand, and the total refusal on the other to admit any case at all, the Committee have endeavoured to arrive at a practical judgment on the question of the relative permanence of papers, which judgment should carry with it a more precise view of the qualities of papers as suited or unsuited to the special purposes for which they are required.

It may be pointed out that the narrower issue of liability to deterioration is no new subject. It is dealt with in general terms in standard treatises on the manufacture and uses of papers. Thus, in Herring's well-known book "Paper and Paper-Making" [Longmans: London, 1856] pp. 97-99, it is pointed out that the unregulated use of bleaching agents has been known to occasion wholesale destruction of papers and books.

Since the period when such results, following from ignorant and careless practice, were common, there has been a great advance in the general grasp of the chemistry of the processes auxiliary to paper making, and the Committee would make no point of such occasional damages as would arise in this direction from accidental circumstances. They have occupied themselves with the question of paper as normally produced, and under the conditions of ordinary wear and tear. The Committee have examined a number of books as practical evidence of "deterioration of paper;" some submitted by librarians in a condition of complete disintegration; some of their own selection exhibiting various grades of deterioration of the paper of which they are composed. They conclude on the evidence before them as follows:—

As to the two tendencies to deterioration of papers, these are marked—(1) by disintegration, (2) by discolouration. They are independent effects, but may be concurrent. They are notably so in papers containing mechanical wood pulp.

1. *Actual disintegration* has been brought to light in papers of all grades; from those of the best quality as regards the fibrous materials of which they are composed, *i.e.*, rag papers: also of course in those of lowest quality, *i.e.*, containing mechanical wood pulp in large pro-

portions. The books examined had in certain cases been subject to ordinary conditions of storage and use: the effect in such cases is independent of wear and tear.* It is the result of chemical change of the fibres themselves. In other cases the damages could be traced to the effects of illuminating gas upon the atmosphere of the rooms in which the books had been stored. It may be generally concluded that all papers are liable to such extreme chemical change, *i.e.*, resulting in disintegration.

As to the causes determining such changes: in the case of the rag papers examined the effects appear to be due to acid bodies: the disintegration may be generally referred to acidity. The acids may have been present in the original paper as made: or may have resulted from reactions going on in the paper itself after making: or lastly may have been due to products of gas combustion. In the case of mechanical wood pulp the effects are traceable to oxidation pure and simple: the disintegration is accompanied by a basic or alkaline reaction of the paper.

2. *Discolouration* may be said also to affect all papers more or less. It takes various forms: the more marked effect is a darkening of colour, which spreads inwards from the margins; but a common case is that of a uniform discolouration. The latter would be the result of changes in the paper itself; the former is determined by external agency, such as by the action of an atmosphere charged with the products of combustion of coal gas. It is a complex effect: that is, while it may be the indirect result of the action of both acids and oxidants upon the constituents of the paper, it is immediately produced by changes in products of such action; or, again, where starch is present in the paper, discolouration may arise from products which this carbohydrate furnishes under the action of acids.

Without discussing minutely the chemistry of the changes, the evidence obtained certainly warrants the general conclusion that discolouration of ordinary cellulose papers (as distinguished from those containing mechanical wood pulp) under usual conditions of storage is proportional to the amount of rosin which they contain, or more generally to the rosin and the conditions employed for fixing it in the ordinary process of engine-sizing.

From a consideration of certain special causes of discolouration it must be pointed

* It may be noted that the cases of destruction of rag papers investigated were for the most part in books produced in the period 1850-62.

out that mechanical wood pulp is stained a deep yellow by aniline and other coal-tar bases; esparto and straw celluloses similarly are stained pink, these effects being due to reactions of the fibre substances with the bases in question. Such compounds are often present in the atmosphere of chemical laboratories or where coal-tar and its products are handled. Papers containing mechanical wood pulp, or esparto, or straw celluloses, are therefore unsuitable for books likely to be used in such laboratories.

Certain practical conclusions of the Committee from the evidence obtainable are submitted. First, as regards the points common to all printing papers:

Sizing (engine-sizing).—Where the printer raises no objection, book paper should be sized with a minimum quantity of rosin. A proportion of 2 per cent. rosin (calculated dry) on the paper may be suggested as a maximum, also that for nearly all the ordinary uses of printing papers, the quality of "hard-sizing" (usually produced with large proportions of rosin), is superfluous.

The presence of *Starch* is objectionable, though, in the case of heavily loaded papers, its employment may be necessary.

Acidity.—The papers may be finished with the normal slight excess of alum, which gives to the paper the slightly acid reaction of the alum, *i.e.*, acid to litmus, neutral to methyl orange.

Chlorides.—Care must be taken that paper should contain a minimum of chlorides.

Colour.—Upon this question it is difficult to make suggestions. It may be pointed out that high whites in papers involving the extreme grades of bleaching of the fibres are in usual practice obtained not only at the expense of strength and elasticity, but often with production of oxidised products themselves extremely susceptible of change with formation of dark-coloured products (discolouration). Such tendencies are, moreover, increased when to the demand for whiteness or purity of colour that of hard-sizing is added; and again, when the third and very usual demand for "cheapness" is considered. This necessitates the use of celluloses other than those of cotton, flax or hemp, in which the dangers of over bleaching are greater in proportion to the lesser chemical resistance of such celluloses, *viz.*, the wood and esparto classes. It is true that these dangers are minimised by graduated methods of bleaching known to practical men and employed in some mills,

but in ordinary practice the question of the permanence of the colour of the paper when made is not much considered. It is suggested that when very white printing papers are required, the sizing should be reduced to the practical minimum; and again, that for ordinary printing papers a lower standard of colour may be adopted with advantage.

Loading.—The addition to paper of mineral matter, such as china clay, has the effect of increasing opacity and improving texture. Up to a point it may be admitted that these advantages outweigh the disadvantages of diluting the fibrous constituents of the paper with inert and non-cohesive material. Above this point the loading of course prejudices the strength of the paper, and generally lowers the qualities of resistance. Moreover, with increase of loading, the sizing agents require to be increased, with attendant disadvantage. After careful consideration, the Committee came to the conclusion that 10 per cent. of total mineral constituents is the *extreme limit* for papers for publications of permanent value.

Texture.—This is purely a paper maker's question. It will only be pointed out here that a close and well-compacted sheet is especially necessary for printing papers. This quality is largely controlled by the mechanical process of preparation (heating) of the fibres; but this is costly, both in time and power, and as the quality is, to a certain extent, to be imitated by the addition of sizing and loading agents, the tendency is towards the latter and factitious methods. The buyer or consumer requires to bear this in mind; and in papers selected for publications of permanent value, to see that close texture has been obtained by the more "legitimate" method of mechanical preparation. The quality is a complex one: it effectually sums up the several "physical constants" dealt with above, and, until "standards" of classification are generally adopted, the question of texture must be insisted upon.

As regards the classification of papers according to composition, or more specifically, the question of the permanence of papers in relation to the fibres of which they are composed; this is a purely chemical problem, and the principles determining the classification have been dealt with in the *Society's Journal*, vol. xlv., pp. 690-696, 1897.

The Committee find that the practical evidence as to permanence fully confirms the classification there given, and that the paper-

making fibres may be ranged in the four classes :—

A.—Cotton, flax, and hemp.

B.—Wood celluloses, (a) sulphite process, and (b) soda and sulphate process.

C.—Esparto and straw celluloses.

D.—Mechanical wood pulp.

In regard, therefore, to papers for books and documents of permanent value, the selection must be taken in this order, and always with due regard to the fulfilment of the conditions of normal treatment above dealt with as common to all papers.

The Committee have been desirous of bringing their investigations to a practical conclusion in specific terms, viz., by the suggestion of standards of quality. It is evident that in the majority of cases there is little fault to find with the practical adjustments which rule the trade. They are, therefore, satisfied to limit their specific findings to the following, viz.—1st, *normal standard of quality for book papers required for publications of permanent value*. For such papers they would specify as follows :—

Fibres.—Not less than 70 per cent. of fibres of Class A.

Sizing.—Not more than 2 per cent. rosin, and finished with the normal acidity of pure alum.

Loading.—Not more than 10 per cent. total mineral matter (ash).

With regard to written documents, it must be evident that the proper materials are those of Class A, and that the paper should be pure, and sized with gelatine, and not with rosin. All imitations of high-class writing papers, which are, in fact, merely disguised printing papers, should be carefully avoided.

TWENTY-FIRST ORDINARY MEETING.

Wednesday, May 18, 1898; CHARLES VERNON BOYS, F.R.S., in the chair.

The following candidates were proposed for election as members of the Society :—

Brunner, Sir John T., Bart., M.P., 9, Ennismore-gardens, S.W.

Buckwell, George William, Board of Trade Offices, Custom-house-arcade, Liverpool.

Kenning, George, Upper Sydenham, S.E.

Maddox, Arnold G., 184, Malpas-road, S.E.

Quirk, Charles James, 16, Westmoreland-street, Dublin.

The following candidates were balloted for and duly elected members of the Society :—

Greg, Arthur, Eagley, Bolton.

Jacobson, Nathaniel, Olive-mount, Cheetham-hill-road, Manchester.

Young, William, Town-hall, Salford.

The paper read was—

THE EVOLUTION OF THE CYCLE.

BY W. K. STARLEY.

Before proceeding to speak on "The Evolution of the Cycle," perhaps I may be permitted to make a few observations upon locomotion generally, with the purpose of ascertaining more clearly what position the cycle occupies in this sphere of usefulness. In visiting old cities, both at home and abroad, one of the things which strikes me as remarkable is how limited the means of communication and inter-communication were years ago, how narrow the roads and how little they were used compared with what they are to-day. Before the introduction of steam vessels and railways operations were conducted on a much smaller scale and a much slower rate of speed, and it is reasonable to assume that the rapid strides which have been taking place during the past fifty years in civilisation, and in the development of the resources of the world, are in no small degree due to the vast increase in the employment of steam power.

It is reasonable to conclude that during no part of the history of the world has there been so much thought and effort expended in enlarging and improving our means of communication; at no time were so many agencies of power utilised for this purpose; but, multiply as we will the number of forces as aids to this end, the principles upon which this purpose may be accomplished are, at the outside, four, practically only three, to float, roll, or carry such bodies or weights. There never was, and there may never be, any agency or principle which has proved so useful as the floating surface. This has certainly been by far the largest and easiest means of communication in the world, and will account for the fact that most of our oldest and important cities were situated near or upon the harbours of the sea-coast, and that even when mines were opened up some distance from the sea-shore, one of the first things was to make a canal or waterway, that operations might be conducted on a larger scale; with the introduction of steam, and its adaptation to vessels,

these were made faster. But, while the development of steam vessels and railways has largely broken down the barriers of distance and rendered operations possible which would have been thought almost impossible fifty years ago, even these most remarkable and efficient agencies have proved insufficient for the increasing requirements of modern civilisation, and probably at no period, notwithstanding this great advance, was there so much time and thought devoted to multiplying, as far as possible, the agencies for cheaper and quicker locomotion.

To fly or glide through the air, it is necessary to exert a force equal to the weight you raise, and seek to propel, but while this is so, roughly speaking, it may be rolled, if placed upon wheels under fairly advantageous conditions, by one-fortieth part of the power it would take to raise it; while a weight may be floated for a one-hundredth part of the power it would require to raise it; indeed, at a slow speed, it might be moved at a one-thousandth part of what it would take to raise it. But while floating is the easiest method, rolling is the quickest, and we must at once concede to the prepared track or railway the perfection of rolling. Now, accepting cycling as a branch of the principle of rolling, we see where the advantage of the cycle comes in. Cycling gives to the cyclist, in point of speed or distance, what is equivalent to three pairs of legs, as it enables a man to travel three times as far as he can walk, for if he can walk three miles within the hour, he can cycle nine miles within the hour, with much the same expenditure of energy. In this estimate I am not taking what a trained athlete can do, but what it is possible for the average man or woman to accomplish; the records which have been made, and the distances which have been ridden, prove that much more than this can be done. I think, however, my statement is sufficient to prove that this in itself is a great advantage, and one which humanity will be slow to give up, for not only can these greater distances be accomplished on the cycle, but there are many who find it is less exhausting to them than walking—indeed, so pleasant is the gliding motion, and so noiseless and easy in its action, that thousands are found who cycle for the mere pleasure they derive from it as a pastime, and not a few are thereby induced to go out into the fresh air and into the country lanes, and obtain most healthful and pleasant recreation which no other means of exercise would afford them.

In taking as my subject "The Evolution of the Cycle" to-night, I may say that in the limited time at my disposal it will be impossible to give a history of the cycle, nor do I think there are many here who would care to listen, even if I could. I think, however, that a review of the types that have been marketed and sold, with a description of those principles and parts of the machines which have contributed to the knowledge which we now possess, and which are actually in use to-day, will suffice. I will therefore proceed to the consideration of my subject upon these lines, and perhaps I may be permitted to say that, although there are, and have been, many mechanical minds, both now and in the past, devoted to perfecting the cycle, this branch of thought is not without its fads, and there are also some who seek to make capital, thus late in the day, out of what were their ideas in former years, although they may never have gone beyond the experimental stage, or may never have been placed before the public at all. It will not be part of my purpose to notice such matters as these; I shall confine myself to those ideas which were marketed, and persevered with, until they became well-known and actual articles of commerce,

Although the bicycle has been before the world for about thirty years, its evolution in the diversity of pattern, with one or two exceptions, may be said to have taken place between its original introduction and 1885. Its perfection, transformation, and the almost complete extinction of all but one class mark the period between 1885 and 1895; since that time there has been little more than alteration of details.

The first attempt at balancing upon two wheels was made by mounting the wheels, tandem fashion, and connecting them with a piece of wood about three feet long, upon which the rider sat midway between the two wheels with the rear wheel fixed, and the front wheel pivoted, steered by a handle, the momentum being set up and maintained by striking the ground in a backward direction with the feet. This machine was known as the hobbyhorse. About the year 1865, Lalle-mont, a Frenchman, conceived the idea of fitting cranks and pedals direct to the centre of the front wheel, and this machine was commonly known as the boneshaker; this appears to have been the first machine to be placed upon the market which had anything like a sale. It was just before the siege of Paris when Mr. Turner (nephew of Mr. Turner,

late manager of the Coventry Machinists' Company) brought such a machine to Coventry; and it was while there as works manager that the late James Starley saw this machine, and, realising what possibilities there were in the development of it, began experiments to change it. It is questionable, however, whether this was the first machine introduced into England, as there appear to have been other minds at work in London and elsewhere, improving, patenting, and endeavouring to perfect the cycle. Although patents were taken out for front driving and rear driving, for ratchet driving and gearing up, very little, if anything, came of these inventions; cycling was largely confined to the boneshaker, the wheels of which were altered in size, and the various details of the machine from time to time improved.

It was late in the sixties when Mr. James Starley applied the first step to a bicycle; before that all the machines were mounted by running alongside and vaulting into the saddle, but by reason of his weight Mr. Starley found it preferable to mount by a step. This was first applied by him and has been in use ever since. He also made a foot-rest instead of a leg-rest. He applied a C-shaped spring, instead of the old-fashioned, almost straight, spring, originally in use, and was, I think, the first man to reduce the rear wheel to reasonable proportions. This machine was made by the Coventry Machinists' Company, and sold as the Coventry Model, thus adding the manufacture of cycles to their business of sewing-machine makers. They were the only firm in Coventry to make cycles at that time.

In November, 1868, patent No. 3469, Bradford mentions the peripheries of the wheels as covered with rubber, or other elastic material, and on the 21st December, 1868, we find that E. A. Cowper took out a patent, No. 3886, for a velocipede, the wheels of which, he states, are made with hollow felloes and steel wire spokes on the suspension principle, and are fitted with rubber tyres.

The suspension wheel was a great advance upon anything which had hitherto been made, and has continued in use ever since. It was made in the first place by heading the spokes, screwing down screw nipples into the hubs, and tightening them with lock nuts. I have been unable to ascertain by whom this wheel was first made, many claiming the distinction. However, it was not long after this that Mr. James Starley and Mr. William Hillman, who were the first to start in the bicycle trade in

Coventry as a purely cycle making firm, introduced a wheel made with flat spokes passed over a wooden rim, to which a rubber tyre was attached. This was the first rubber tyre to be fitted to velocipede wheels in Coventry.

The next wheel of distinction was the Aerial, patent No. 2236/70, Starley and Hillman, the spokes of which were made in pairs, constructed in such a way that all the lateral pressure on the spokes set up by pedalling was removed from the spokes by a tension lever connected to the rim. This patent also contained a method of gearing up the front wheel of a bicycle by the application of toothed gearing, and was constructed in much the same way as the present geared ordinary or Bantam, and soon after I went to Coventry in 1872, I rode such a machine very frequently. It was known as the Geared Bicycle, and I believe one championship was won on this make of machine.

In 1874, Mr. James Starley, who had continued experimenting upon wheels, introduced the tangent wheel, patent No. 3,959, which has been in use ever since; for although the details of its manufacture have varied somewhat considerably, the principle upon which it is built has never been departed from, and few machines are now made which are not fitted with tangent wheels. The introduction of this marks a distinct development in wheel-making, and it will be seen that, early in the history of the cycle, Mr. Starley foresaw the necessity of bringing the driving pressure on to the spokes by a direct pull. This method of construction admits of very much lighter spokes being used than could be fitted if direct spokes were employed, and it is probable that the double-butted spokes in such universal use could never have been introduced but for the perfect principle of this wheel.

Although I have tried to ascertain who was the first to fit velocipede wheels with rubber tyres, I have failed to do so. Many claim the honour. The first must have been fitted, however, somewhere about 1867 or 1868, and although in the first instance such tyres were generally placed upon a flat rim, and fastened by nails or rivets, or some such device, it was not long before a V or U shaped rim was used, into which the tyres were placed and fastened with cement.

Several attempts were made to fasten tyres with wire, and many were made with a hole through their centre; wires, the ends of which were secured in various ways, were used, but nothing succeeded until Hookham con-

ceived the idea of corrugating the wire and springing the tyre into the rim.

The solid tyre proved such a great advance over anything else known that for years it was used with little variation other than in size or diameter.

For several years inventors had been endeavouring to apply anti-frictional bearings to reduce friction, and many ingenious devices were tried. The bearings were usually made in a true circle, instead of being made in two halves as originally, but with the introduction of such circular bearings, the necessity for a crank that could be attached and detached was of vital importance, and it was at this time I took out my first patent, No. 4478, 1876. This new crank was attached by a transverse key, which speedily became almost universal in its application, and has been in use ever since, for notwithstanding one or two other methods are employed for the purpose of attaching a crank, the transverse key may be said to be the most satisfactory of any principle which has yet been used. It is worthy of note, too, that little, if any, alteration has been made in the manner of fastening the key; nor does there appear to be any likelihood that cranks attached in any other ways will be generally used, few inventions having proved more permanent and useful than this detachable crank.

Although several of the circular bearings found a moderate sale, it was not until the merits of the ball bearing, patented by Hughes in 1877 (3531), and introduced by Bown, had become known, that this bearing slowly but surely occupied the whole field, for when Hughes succeeded in making this adjustable, its simplicity, both in vertical and lateral adjustment, was so perfect, and the ease with which it could be made and adjusted to ensure a perfect fit speedily secured for it the premier position amongst all bearings, and it is not too much to say that to the inventor of this is due a large share of the credit for the perfect cycle which we have in use to-day. From its application to the front wheel it was carried to the back wheel, and ultimately to the pedals, until there is no cycle bearing now in use that is not made in this way. No cycle, whether bicycle, tricycle, tandem, or triplet, could be sold unless fitted with this bearing, and probably, with the exception of the pneumatic tyre, there is no portion of a cycle which plays a more vital part in its ease of running than the ball bearing. Few inventors in the cycling world can be said to have achieved so much

as Hughes by this addition to the perfection of the modern cycle.

From solid forgings the framework of the machine came to be made of tubing, and from welding such parts, brazing rapidly took its place. Although the fork, sides and backbone were made in this way, it was some few years before the back fork or the steering head, pivot, and handle-bar were made hollow, and the ordinary bicycle still continued to hold the field.

In 1874, patent No. 3959, we find, for the first time, a bicycle introduced for the use of ladies. Mr. James Starley conceived the idea of making a machine having two pedal levers placed on one side of the wheel; the backbone of this machine was cranked with a Z-shaped crank: the saddle was mounted half-way along the centre, that it might be easily mounted, and the back wheel was carried out behind as in the form of an ordinary bicycle, except that the two wheels did not track; the back wheel was placed about eighteen inches out of line of the front wheel. It was tricky in its steering, and the idea of placing a third wheel in front led to the introduction of the Coventry tricycle, of which I speak later. The pedal levers were attached to the front wheel of this machine very similar to the manner of the 'Xtraordinary, except that they were both on one side of the machine. The patent states that two sets of levers may be used. It will be seen that this marks the date at which a sociable bicycle was first thought out and designed.

About June, 1876, Messrs. Likeman and Lawson took out a patent, No. 2649, for a safety bicycle driven by levers attached to the back wheel. This may be said to have been the first safety bicycle which was made and marketed. The machine was manufactured by Singer, and had a limited sale, but did not continue as a marketable machine for very long. The pedal levers were worked in much the same way as on Starley's bicycle, but were placed nearer the ground, the machine being made in such a manner that it could be mounted from the ground; indeed, having such a large wheel behind, it could hardly be mounted in any other way.

In November, 1876, Mr. Starley took out a patent, No. 4478, for the Coventry tricycle, which was suggested to him by the lady's bicycle to which I have before alluded.

This machine was made with a large driving wheel on one side, mounted on a double-throw crank, to which were attached adjusting rods,

to be connected with the pedal levers by which the machine was worked. On the opposite side of the machine were two small wheels mounted in sockets; these were connected by a rod which crossed from one side to the other, so that when it was desired to turn a corner, if the front wheel was turned to the right, the rear wheel was turned to the left. This may be said to be the first tricycle made which obtained a successful run in the market. It was driven from one side only, and steered by a bath chair type of handle. The two side wheels, being placed some distance apart, caused the machine to run very steady.

The Coventry tricycle was speedily followed by Blood's Dublin tricycle, which was made with a rear driving wheel placed centrally, and this was also driven by levers similar to the manner of the Coventry tricycle. The two front wheels were pivotted in such a way that the inner wheel always described a smaller circle than the outer wheel, whichever way the machine was turned.

This was an ingenious device, and the method of connecting these two wheels has been adopted in all tricycles driven by the back wheel since that time. The Dublin tricycle was, I believe, made by Messrs. Hillman, Herbert and Cooper; it had a very limited sale.

Not long after this, Mr. James Starley made a sociable tricycle, which may be described as being a double Coventry tricycle, with a large driving wheel on each side, and the double-throw cranks working independently to enable the machine to be turned round corners. This was really the first successful sociable made. It had a moderate sale. While testing this machine he found what a loss of power resulted from the side thrust when the pedalling of the riders was not in unison, and it was to overcome this defect that he turned his mind to a different method of driving. In September, 1877, he took out a patent—No. 3388—for the Salvo tricycle, which was the first machine constructed with double driving-gear. It was made in the following manner. The two large driving wheels were mounted on an axle, one firmly attached to one end of the axle, while at a convenient distance near to the other end was attached a bevel wheel. The chain wheel which was mounted on the axle carrying a pinion was geared into this bevel wheel, the driving wheel which fitted on this side of the machine was also fitted with a bevel wheel, and this in its turn was geared into the pinion on its opposite side. A double

throw crank, having at its end a chain wheel corresponding with the chain wheel on the axle, was suitably mounted, the two being connected by a chain. On applying power to the crank, the chain wheel with its pinion was driven, and the pinion imparted an equal pressure to both bevel wheels, thus imparting motion to the driving wheels, and in this way both wheels were driven. On turning a corner, when it became necessary for one wheel to travel faster than the other, the pinion mounted in the axle chain wheel simply revolved in the teeth of the bevel wheels. This was the first time a tricycle had been made where the two side wheels were thus driven, and so perfect was this in principle that no successful tricycle has ever been made with the two wheels driven without this method. It is impossible to over-estimate the impetus this wonderful invention gave to the tricycle, and from that time the demand for them increased at a rapid rate. It may be said to have formed a turning point in the history of the tricycle, and the Salvo, the machine to which this was first fitted, speedily became famous.

Now it will be noticed that until this time a lever action was universally used, but with the introduction of the Salvo balance gear and its chain a rotary motion was introduced for tricycles in place of the lever action, and although alternative mechanism and devices have been tried from time to time, nothing has yet succeeded in taking the place of this rotary pedalling, whilst the chain to-day may be said to be in universal use for bicycles, tricycles, tandems, and triplets, and, indeed, for nearly every saleable machine. The application of the chain, therefore, marks a very extraordinary epoch in the history of the development of the cycle, and the ease with which the wheels can be attached and detached and varied in size, so that a higher or lower gear may be obtained, renders it one of the most perfect and efficient methods of transmitting power at present known.

It is worthy of special note that it was on the Salvo tricycle that the first chain was ever applied to a cycle. At the time Mr. Starley introduced it he did not know where a chain could be procured; and he therefore had to make the first few chains with his own hands. It was not long, however, before a Manchester firm began to supply them. They were known as roller chains, and had two outer links, to which studs were secured, and two inner links, mounted loosely on the larger diameter of the studs, having a bowl or roller to work on the

studs between the two inner links to keep them the right distance apart. It was not long after this chain began to be used that I conceived the idea of making chains with this sleeve or bush to be passed through and attached to the inner links, so as to form a broader bearing and wearing surface which should fit the whole length of the large diameter of the stud, having in turn a loose bowl on the outer diameter of the sleeve. About this time Mr. Hans Renold conceived the idea of making a chain in this way, and brought such a chain to Coventry for me to see. On telling him that I had suggested the idea to a rival maker, he very kindly allowed me a royalty on all chains we used. It is worthy of note that at the time this chain was introduced it was made with a $\frac{5}{8}$ in. pitch, very similar to what is now in use, except that it was not so perfect in detail.

The Salvo was also the first machine to be fitted with a band brake, a powerful and efficient means of controlling the machine, which was almost universally applied, and continued in use for many years.

With this machine was also introduced the rack and pinion steering. This was constructed in the following manner. A spade-shaped bracket was attached to a spindle, to which was affixed a small pinion. The steering wheel was mounted in a socket having an arm extending on one side, to which was attached a toothed rod or rack. This rack was connected with the pinion, into which it was geared. To steer the machine the handle was turned to the right or left, according to which way the machine was desired to travel, and this principle of steering was applied almost universally to all tricycles for several years.

In the early history of the bicycle, when a long reach was required, the saddles were mounted on flat springs, and were made by simply placing leather over a bent sheet of steel, with little or no padding between. In 1878, Messrs. Lamplugh and Brown introduced a saddle in which the leather was suspended above the saddle plate. This was known as the suspension or long distance saddle, and all saddles have been made upon this principle ever since.

In 1879, Harrington introduced his cradle spring, patent 3849, by which a coil and S-shaped spring was fitted, and this had a good run. Afterwards, on the introduction of the tricycle, there being more room for the purpose of applying a saddle and spring, many were the devices set up to obtain greater elasticity and ease. Springs of all kinds came

in for their share of attention, while a double-plate with three coil springs attached to a vertical saddle pin secured a passing success. It was speedily found that a combination spring and saddle was after all the best, and this form of saddle is now almost universally used.

In 1878, Doubleday and Humber patented the Humber tricycle, patent No. 3126. This machine had two front wheels, one of which was driven by a chain. Later on it was fitted with Starley's balance gear. A backbone, carrying a back wheel, was pivoted to a pivot head placed at the centre of the axle. A spring and saddle were mounted on the backbone, upon which the rider sat to pedal and guide the machine. It was steered by an ordinary bicycle handle-bar, which turned the whole of the front part of the machine, including the pedals. It was on this machine that central chain driving was first introduced. Up to this time all machines which had been driven by Starley's balance gear were connected by the chain at the side of the machine instead of the centre. The chain running on the side wheels, motion was imparted by pedalling a double throw crank. These cranks were somewhat cumbrous and heavy. But in central chain driving, introduced on the Humber tricycle, a narrow bracket, containing ordinary bicycle ball bearings was fitted, together with ordinary bicycle cranks and pedals; these were much neater and lighter, and although there was no new principle introduced it was, from a mechanical point of view, a great advance in cycle construction upon anything that had been produced before, and this tricycle, upon which the rider obtained a bicycle position for pedalling, had much success. The machine, however, having to be held true by the hands, caused a certain amount of strain to be set up to keep the wheels straight, notwithstanding which it was one of the most favoured tricycles.

It is worthy of note that the central driving, introduced by Humber on this machine, has been in use for driving tricycles ever since, with no alteration except in a few details. It must therefore be regarded as having in no small degree helped forward the perfection of the modern tricycle.

In 1878, Mr. Singer took out a patent No. 4265 for a bicycle he called the 'Extraordinary. This bicycle was made in much the same form, and with wheels similar in size to the ordinary bicycle, but the front forks were sloped backward. It had two rocking levers, one placed on each side of the forks, to which were

attached two pedal levers, in turn attached to the cranks, which were fitted to the centre of the driving wheel. The pedal-levers were extended back some distance to the rear of the front-wheel axle, so that, although the rider sat in a much more backward position, the pedals were carried well under him, and he could exercise great pressure upon them. So comfortable and safe was this machine, and free from headers as compared to the ordinary, that it soon became a great favourite, and had a large sale for several years.

The 'Xtraordinary may therefore be said to have been the first successful bicycle which was driven other than by the pedal crank attached directly to the centre of the front wheel.

The demand for tricycles now having largely increased, and it having been found inconvenient to store them, a demand arose for a tricycle which could be made to fold up or take to pieces. To meet this demand J. M. Starley and myself took out a patent in 1878, No. 4658, for a tricycle which was known as the Compressus. This new machine was constructed in such a way that it could be divided into two parts, and the two large wheels folded close to the framework. By this means the whole thing took up very little room. The Compressus was driven by a chain connected to the front wheel of the machine, and was the first machine to be made geared up with the chain driving.

This machine was speedily followed by the Compressus No. 2 and the Tom-tit, both of which met with a fair demand.

In 1879, I also made a tandem in this way, with the rear portion detachable so that it could be removed at will. This machine was the first that had a front or rear central driving wheel, geared up by a chain.

In the same year H. J. Lawson took out a patent for the Bicyclette. This machine was driven from the back wheel by a chain, and was so designed that the rider could sit low to avoid headers. The Bicyclette was merely geared up to the level of an ordinary bicycle, and ordinary bicycle cranks were fitted. Nothing was claimed for it except its safety from headers, and although it was placed upon the market, it never had a sale, and speedily went out of existence. Amongst bicycles the Ordinary and the 'Xtraordinary were still holding the field.

In 1878, Messrs. Ellis and Co. introduced the Facile. This was a machine made with a smaller front wheel, mounted in forks having extensions projecting to the front of the

machine, to which were attached connecting rods, in turn connected by short cranks affixed to the centre of the driving wheel, so that the pedals were taken further back than on an ordinary bicycle. By this device the rider could sit both lower and further back, and in a safer position.

This machine may be described as an 'Xtraordinary bicycle on a small scale, but having a safer position elderly riders took to it, and it proved a great favourite for several years, and largely increased the number of those who cycled.

This machine was the first successful machine of the safety class; yet, like the 'Xtraordinary, one revolution of the pedals imparted one revolution only to the driving wheel, consequently it had to be pedalled very fast if anything like speed was to be obtained.

The demand for tricycles, however, was largely on the increase at this time, to meet which Messrs. Bayliss and Thomas introduced the Excelsior.

This machine was known as the hay-fork pattern frame, and was the first of its kind, and was introduced 1878. Its absence of uniformity caused many to ask for a machine made with wheels of equal size, to meet which Messrs. Starley and Sutton introduced the Meteor tricycle. This machine was designed on the lines of the Excelsior, and was copied by many makers; it had a large sale for several years. It was on this machine I introduced the first L seat pillar, which has been in universal use ever since.

While this machine was in vogue, the Coventry Machinists' Company introduced a machine identical in shape, with driving ratchets and pawls, and two chains, by which both wheels were driven when running in a straight line; on turning a corner the wheel which ran the quickest was free to run forward, and this machine had a very good sale.

Some little time after this, Mr. T. Humber introduced the Cripper tricycle; this machine was constructed with two rear wheels driven by a balance gear, as in the Humber tricycle. It had a small front steering-wheel, while an ordinary bicycle handle bar was connected by a direct connection with this wheel. The socket tube, carrying the handles, sloped backwards, and was known as the sloping steering-post. This was the first machine made with the handles sloping backwards in this way. Up to the time of its introduction nearly all the machines, whether rear-steerers or front-steerers, had been steered by a rack and

pinion, so that this sloping steering-post marked a distinct era in the history of the cycle, for no double-driving tricycles have been made since except in this way, while for the present form of bicycle, the sloping steering-post is in universal use, and must be classed as one of the things which have contributed in no small degree to the perfection of the modern cycle, both bicycles and tricycles.

Towards the latter end of 1883, Messrs. Hillman, Herbert, and Cooper introduced the Kangaroo.

This was built on the lines of an Ordinary, and, like it, was driven by the front wheel, but instead of the cranks being attached to the centre of the front wheel, the front wheel was mounted in a fork, having extensions reaching down on each side, about 9 in. below the centre of the wheel, such extensions being mounted with ball bearing brackets which carried a crank on the outer side and a chain wheel on the inner side both sides of the machine. The front wheel hub was made to run loosely on the spindle, and had a chain wheel placed on each side of it, so that the cranks fitted to the fork extensions could be connected by two chains, and the chain wheels could be made of variable sizes, enabling the machine to be geared up. This was the first time a safety bicycle was successfully produced in which, by one revolution of the crank, the driving wheel travelled further than the driving wheel of an Ordinary bicycle. Not only did it establish the principle of gearing up a bicycle, but it was the first cycle upon which was introduced longer cranks, about 7 in., for, in the desire to reach the higher machine in the days of the Ordinary, not only was the saddle mounted low, so as to get a longer reach, but very often the cranks were made very short, so that a short rider could reach a higher machine and travel at a quicker speed; but by gearing up the Kangaroo, not only could the crank of an ordinary length be used, but a crank longer than the normal length was speedily fitted, and the machine was geared up to a higher rate of speed than had ever been before used on a bicycle. It is no wonder that this machine had an enormous run. During the year 1884 there were few first-class makers who did not make a like pattern, and new records and a number of long distances were ridden, which could never have been achieved on the ordinary bicycle.

Notwithstanding the great demand for this machine, the sale for tricycles continued, and in 1883 I introduced what was known as the

Rover tricycle. This was largely on the lines of the Humber, except that it was steered by the back wheel. This contained, for the first time, the position which was embodied in the Rover bicycle later on.

A large number of different patterns were manufactured about this time, bicycles and tricycles in various forms, together with carriers, sociables, and tandems were in great demand; but the year 1884 was a Kangaroo year. Records were made upon this machine which proved its superiority in speed over any bicycle previously introduced, and a large trade was being done by its introducers, other makers also copying it. Although I was urged on many occasions to make such a bicycle, I felt the time had arrived for solving the problem of the cycle, and I resolved to make a bicycle embodying the principles introduced in the Rover tricycle. I therefore turned my attention solely to the perfection and manufacture of the Rover bicycle.

The main principles which guided me in making this machine were to place the rider at the proper distance from the ground; to connect the cranks with the driving wheel in such a way that the gearing could be varied as desired; to place the seat in the right position in relation to the pedals, and constructed so that the saddle could be either laterally or vertically adjusted at will; to place the handles in such a position in relation to the seat that the rider could exert the greatest force upon the pedals with the least amount of fatigue; and to make them adjustable also. In the Rover, these, my cardinal principles, were all carried out, and although many alterations and improvements have been since effected in detail, it is a fact that there is not more than two or three inches difference to-day in any of the points first embodied in the Rover.

At the time this machine was introduced, it created a certain amount of ridicule. It was so different in design from anything else made. It was not long, however, before we determined to prove that it possessed qualities which had never before been embodied in a cycle. In September, 1885, we broke the world's record for one hundred miles on the road. From that day to this we have had with it one uninterrupted and ever-increasing success; while we have the satisfaction of seeing that all cycles, with the exception of the Bantam, whether driven by the front or back, or by the side wheels, have slowly but surely had to give way before it, until there is not a bicycle,

tricycle, tandem, triplet, or quadruplet which is not manufactured substantially upon the same lines.

Writing upon this machine in the "Year Book" for 1885, Henry Sturmev says:—"It is both safe and fast, and when used to the steering, possesses quite a number of unforeseen merits."

The same writer (Mr. Sturmev), in an article on "Wheels of the Period," also in 1885, says:—"Amongst the foremost firms in Coventry to introduce 'good things' are Starley and Sutton, whose name, it will be remembered, came so much to the front a few years ago with the introduction of the Meteor tricycle, a pattern which, although now very nearly obsolete, was at that time about the most satisfactory till then placed on the market, and the success of which led to its being made and sold by nine out of ten firms in the trade. In the Rover safety the firm have again made a step forward, and struck out on their own account in a line which will, without doubt, find many parallels in the season to come. At a time when nearly everyone seemed to think of nothing else in the 'safety' line than making, with more or less variations, the new star—the Kangaroo—Mr. John Kemp Starley, the mechanical genius of the firm, steadily refused to join in with the crowd, and fixed his mind on something new. During the previous season his firm had introduced a tricycle known to fame as the Rover, in which the rider was placed very much over, and almost in front of, his work, and experience with this machine had shown that this position of the rider rendered the machine a wonderfully good hill-climber. Keeping this in view, Mr. Starley contended that the position which had proved good on the tricycle should prove of equal value on a bicycle, and set himself to work to attain that end. The ordinary pattern machine, with backward sloping forks, rendered its adoption impossible if the desired point were to be attained, and Mr. Starley had perforce to direct his attention in a direction hitherto almost untrodden, and work upon quite a different principle. This principle consisted in driving with one wheel and steering with the other, a principle already embodied in one or two new patterns then just placed on the market. His mechanical eye and practical knowledge led him to discard the small steering wheel, however, and although it looked ugly and required well staying, to adopt a large one; this he did, and by placing both driver and pedals between the two wheels—

practically as in the boneshaker of old—not only saved vibration but mechanical force."

Mr. A. J. Wilson ("Faed"), writing about the same time on "My Experiences of Safety Cycling," says:—"The Rover, which I have purposely left until the last, is, in my opinion, the best of all the dwarfs. It is safer than even the 'Xtra, easier to mount and dismount because nearer to the ground, has less vibration than any other dwarf, and is unquestionably very fast. I find that I can fly *uphill* at a great pace on the Rover geared *up* to 65 inches."

For 1887, Mr. Sturmev says:—"This is the pioneer of this now universally popular style of machine—it led the way, and others followed."

In the Badminton book on "Cycling," 1887, the writer says:—"The Rover safety, introduced by its makers, Messrs. Starley and Sutton, in the year 1885, has made such rapid progress in the public favour that it deserves very full mention. Here, undoubtedly, the makers have succeeded in producing a machine which fully deserves the term of 'safety,' and at the same time have in no way sacrificed speed. In the latter quality it will hold its own *on roads* with any make of cycle, whilst in the former, it and its type stand alone."

Further, it says:—"Now this machine possesses the following qualities, which will be taken in detail: safety, absence of vibration and side-slipping, easy steering, a narrow tread, a single chain, a good luggage carrier, and, lastly, speed."

On the subject of chains it says:—"Chains will stretch and will collect dirt; they are necessary evils in tricycles and geared-up bicycles, and the less one has to do with them the better; but it is manifestly an advantage to have one to adjust instead of two, as in the Kangaroo type. The Rover has a unique and very simple plan of adjusting the chain. This is effected by moving the back wheel backwards or forwards as required."

For although the introduction of the tricycle added considerably to the number of those who cycled, and the Facile and Kangaroo also brought a large additional number of riders, at no time in the history of the cycle was there anything like the extraordinary increase which took place when the merits of the Rover became known. It is, therefore, with considerable pride and satisfaction that I now regard the fact that my firm was the first to send this type of machine into America, France, Germany, Italy, Austria, Switzerland, Australia, India, &c., so that not only has it been

the forerunner of a large expansion of trade, but, in the words of *The Cyclist*, it may truly be claimed to have "set the fashion to the world."

It was with this machine that I introduced the rational bar with turned back and sloping handles, and with grips such as are now in universal use. Before this time all bicycle handle-bars were straight, and the grips pear-shaped, or what was known as the spade handle, but to ensure in all details the comfort of the rider, I determined to omit nothing which would in any way add to the pleasure and comfort of riding this machine. There are few things more remarkable than the universal use of these handle-bars and sloping grips. So true were my calculations with regard to the requirements of this machine, that little by way of improvement has been possible. For a long time Humber and many others made a machine on similar lines to the Rover, with a small front wheel, ultimately to be discarded for the larger front wheel.

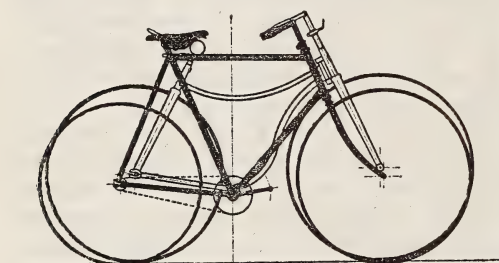


FIG. 1.

The Rover was speedily copied by most makers, but while such copies were made without direct connection between the two chain-wheels, the Rover has, from the first, always been made with this connection, and also a direct connection between the back wheel and the seat. The illustration which I now give will show the essential difference between the two frames, viz., the racing Rover of '85, and the modern machine of '98 (Fig. 1), and will, I think, prove conclusively that when I introduced this machine, my aim was not only to make a safety bicycle, but to produce a machine which should be the true "Evolution of the Cycle," and the fact that so little change has been made in the essential positions, which were established by me in 1885, prove that I was not wrong in my estimate of the cardinal points to be embodied to this end. It will be seen that whereas I made a machine with curved tubes, it is now made with straight tubes. I have never had any doubt as to the

future of this machine, nor have I ever felt that any serious rival could take its place.

The illustration which I now give will show what was running in my mind at this time. I had been considering what a man could be compared to pedalling a bicycle, and the conclusion I had formed was, it largely resembled walking up a ladder, but with this difference, that whereas the pedals went down in the former, the man went up in the latter. I therefore had to determine where the handles should be placed to enable him to bring the whole of his weight on to the pedals, and, I think, the illustration will show my selection was correct. It was this question of the handle-bar which compelled me to adopt the present form of machine, as I could not get it sufficiently forward by the other type. It will be seen by the position of the handle-bar on

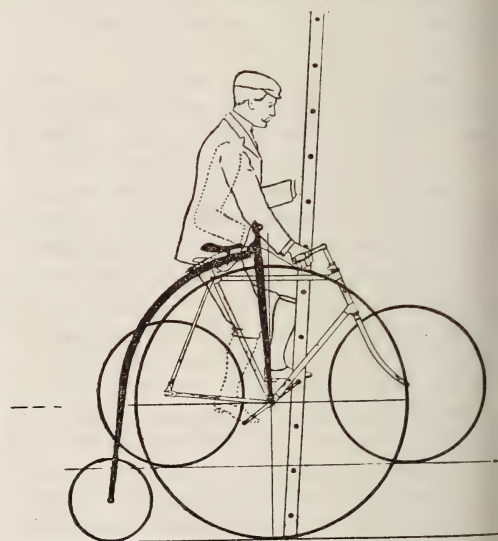


FIG. 2.

the ordinary bicycle, that it was utterly useless and imperfect for this purpose.

I have dwelt at some length at this point in the "Evolution of the Cycle," as so much interest is centred in the modern cycle, and so many misstatements have been made concerning it, that it seems to me desirable that a few quotations, which cannot be controverted, are essential and desirable to place the matter on a true and proper footing.

In 1888, Mr. J. B. Dunlop introduced the pneumatic tyre, which may be said to have formed another distinct epoch in the evolution of the cycle, for we were thereby enabled, for the first time since the introduction of the old solid tyre, to work upon an entirely new field of

improvement, viz. : to overcome the obstacles which were met with on the road.

Since the general application of this tyre, districts in which cycling could not be enjoyed have been opened up, and riding—which would have been more or less difficult—and touring can now be indulged in with a fair amount of luxury.

The popularity of racing, too, increased to an enormous degree with the introduction of the pneumatic tyre, and fast times were made upon tracks so rough that only a moderate speed could have been obtained by the use of the solid tyre, and as speeds became faster and faster, tracks were improved, and banked at the outside higher and higher; pacing became better and better, until purely pacing teams began to be used, with a result which can be appreciated from the following:—

COMPARATIVE TABLE OF RECORDS.

Path.	1884.	1898.
$\frac{1}{4}$ mile ..	35 2-5ths.	23 sec.
1 „ ..	2 m. 41 2-5ths.	1 m. 35 sec.
5 „ ..	14 m. 18 sec.	8 m. 50 4-5ths.
10 „ ..	29 m. 30 2-5ths.	17 m. 47 1-5th.
25 „ ..	1 h. 10 m. 41 2-5ths.	45 m. 19 2-5ths.
50 „ ..	2 h. 43 m. 55 sec. ..	1 h. 34 m. 45 2-5ths.
100 „ ..	5 h. 50 m. 5 2-5ths.	3 h. 25 m. 21 4-5ths.
12 hrs. ..	No record.	317 miles 600 yds.
24 „ ..	No record.	616 miles 340 yds.
Road.		
12 hrs. ..	Not timed.	226 $\frac{1}{2}$ miles.
24 „ ..	266 $\frac{1}{2}$ miles.	411 $\frac{1}{2}$ „

It is reasonable to conclude that the pneumatic tyre has added about one-third to the speed of the cycle, though for sustained efforts the absence of vibration shows an even more marked difference, but I think part of this must be put down to the improvement in tracks and pacing, for which not a little credit is due to Messrs. H. J. Swindley and G. L. Hillier, who have done so much in this field.

In 1888, Mr. Harrison Carter introduced the oil-tight chain cover. Although several attempts were made to cover in the chain, nothing was seriously attempted until this time, and most of the chains had been efficient in use, but they had been allowed to run partly, if not wholly, exposed to the dirt and grit which was met with on the roads. From the dirty and clogged-up appearance of the chains, after a long and sustained ride, he felt confident there

was a great loss of power, and it was to remedy this defect that he introduced the dust-tight and oil-retaining case. This device proved so very beneficial that few of the best machines are now made without it, or some similar covering such as the leather case introduced and made by J. Grose, of Northampton.

It will be readily understood that there are machines and details, and many ingenious devices, which have been tried at different periods, which might well have come in for review but for the small space of time which I have had at my command. I have, however, deemed it more useful to take those things only which are used to-day in the modern cycle. The lady's bicycle, too, although containing nothing new in principle, deserves more than passing comment, for it is a good thing that ladies took to cycling, as the position in which they sit is much more graceful than that usually practised by the average cyclist.

The Rover Cob, too, deserves more than passing mention, as it was the first machine made which could be mounted from the ground without the use of a step, and it is a machine upon which the most timid may venture with little or no fear of a fall. The cranks are placed low to prevent a bent knee when riding, as the straighter the leg the greater the power obtained, and it cannot be too clearly pointed out that a cycle being built low in the upper part of the frame, similar to those used a few years ago, can in no sense be said to have the principles of the low cranks embodied in the cob.

Having thus briefly described all the machines and points in detail, I am of the opinion that the types which have contributed most to the “Evolution of the Cycle” are—

The Ordinary,
The 'Xtraordinary,
The Facile,
The Salvo,
The Humber,
The Kangaroo,
The Cripper,
The Rover,

while the step, the tangent wheel, the ball bearing, the detachable crank, the combination saddle and spring, the chain gearing, the sloping steering-post, the position of the pedals, seat, and handle-bar, the present form of handle-bar, the pneumatic tyre, together with the double driving axle and central driving for tricycles, form the whole of the points of value in the cycle of to-day, the position of the rider, whether using bicycle, tricycle, tandem,

triplet, or quadruplet is essentially the same as in the Rover, introduced in 1885, and although justice cannot be done to those patient workers who have contributed so many details of the present day machine, those points which I have reviewed form the vitals and essentials in the evolution and perfection of the modern cycle.

To obtain the information which I have been enabled to lay before you, I have been greatly helped by Messrs. H. Sturmev, G. L. Hillier, H. J. Swindley, J. Hughes, J. B. Dunlop, H. W. Staner, and many others, to whom I now offer my best thanks.

DISCUSSION.

Mr. ARCHIBALD SHARP said Mr. Starley was to be congratulated on this paper, and also on the share he had taken in the introduction of the cycle, while the English nation might be congratulated on the fact that the evolution had taken place almost entirely in this country, though America was certainly competing now in the commercial side of the matter. It was interesting to note that evolution in the mechanical world, as in animate nature, depended to a great extent on external circumstances. In this country we had possessed inventive skill, commercial enterprise, a number of good roads, and a dense population, and each of these factors had been essential to the evolution of the cycle. The other countries which were in the forefront in this matter, France, Germany, and the United States, possessed some of these qualities, but none of them had the entire combination. Again there were accidental circumstances which determined whether development should take place or not, and it was fortunate that in this country the coaching interest did not possess the strong Parliamentary power which the railway interest did fifty or sixty years ago, when it simply killed the development of locomotion on roads by steam power. He thought Mr. Starley had wisely omitted any reference to what must be termed the freaks of cycle development, but he should like to ask him if the sociable unicycle, of which a slide had been shown, had ever been ridden, and if so to what extent.

Mr. H. STURMEY said this paper gave the history of the development of the cycle in a clearer way than he had ever heard it put before, and would certainly prove of great value to future historians. Mr. Starley had left practically nothing untouched which had taken a commercial form, and thus had had any real effect on the development of the machine. Some things were called freaks which were merely before their time, and the cycle itself at one time was in that position. There was a period of activity about 1860-70, in which the Press spoke of the cycle craze much as they had done more recently, but at that

time the phrase was more correct, because the machine was comparatively undeveloped, and the passing excitement died out for a time. There was a tricycle called the Rantoon, which at one time was very popular, and he remembered seeing a gentleman in 1869 coming from Weymouth on one, with a valet on another, carrying the baggage for the two. As the machine probably weighed about 200 lbs., they would all agree in pitying the valet. Again there was a curious machine called the Phantom, which worked on a hinge in the centre, which was very nice to ride so long as you kept your head, but if you got the least excited it was apt to land you in the ditch. From 1870 to 1873 the cycle almost died out except amongst a few enthusiasts who stuck to it, and then came the period of development, of which Mr. Starley had spoken. He should like to lay special stress on the influence of the Facile in paving the way for the Kangaroo, and subsequently for the Rover, and more especially for the pneumatic tyre. The Facile was the first successful small-wheeled machine, and the records accomplished on it and afterwards upon the Kangaroo, showed the value of small wheels, so that when the Rover came along the public were prepared for it. If they had been restricted to large wheels they would scarcely have had the pneumatic tyre. He invented one himself in 1872, but abandoned it simply because it was altogether too heavy. Mr. Starley had not shown one of his earlier forms in which he made the same mistake as Mr. Lawson, of having a vertical steering post, and connecting the steering by links or lines; he was quite right in saying that the slanting steering post was the making of the machine. Several people, at various times, had hit on other of the various elements of the present safety, but no one combined them all in one machine before Mr. Starley. Even then, it by no means took the public fancy all at once, and he well knew the struggle Starley's firm had in early days: but they stuck to it right through, knowing they were in the right, and eventually came out on top, and drew the whole trade after them.

Mr. R. E. B. CROMPTON said he began to make self-propelling machinery, to be driven by steam, in 1861, and he found on the roving frames in Leeds what had been described to-night as the differential gear universally used for tricycles, and he believed he was the first to put it on a road-engine, but it had been used on traction-engines ever since. It was a very beautiful invention, but there was no doubt it came from the traction-engine. In fact, almost every great feature which had been described had been previously worked out on a large scale in the development of road-engines. It was to the traction-engine industry they owed the rubber tyre, both in the solid form and the pneumatic. He was, perhaps, the only man in the room who knew the late R. W. Thomson, but he remembered having many discussions with him as

to the best way of making a wheel take up the vibration of the road, and Mr. Thomson, as was well known, made a pneumatic tyre which was a success in every respect but one, the liability to puncture, which he was not then able to overcome, so that the thing was dropped. Mr. Thomson was a great genius, and he got over this difficulty by employing large masses of solid rubber for the wheels of his traction-engine, and then he (Mr. Crompton), who was ordered by the Indian Government to use those engines, encountered much the same difficulty with those wheels that the pneumatic tyre people found later. He had ridden a boneshaker, and a Rantoon which did not weigh more than 120 lbs., and then about '68 he dropped cycling, and only took it up again a few years ago. He now came to somewhat dangerous ground, but he must say that in his opinion manufacturers had not arrived yet at anything like perfection, either as regards speed or comfort. Two years ago, one of the greatest electrical engineers on the continent, Otto Blathy, wrote a letter in the *Cyclist*, in which he advocated the use of longer cranks, and the designing of each cycle to suit the man who had to ride it. He wrote to him on the subject, and got from him a specification for a bicycle, which he had the greatest difficulty in getting carried out, several makers positively refusing to make it. Ultimately, however, the Referee Company and Mr. Morris made the machine, and he rode it, and had ridden it ever since. It had enabled a man of his years to do what comparatively few young men did. What was the cause of this? It was not the long cranks only, nor the gearing, but the fact that in order to work comfortably with these long cranks, he had had to alter the shape of the frame, and to study the whole question of what was the perfect relative position as regarded the pedals, the saddle, the length of the frame, the length of the crank, and the ratio of the gearing, so that the rider's muscular power might be exerted with the greatest advantage, and that he should produce the maximum effect with the minimum fatigue. Manufacturers simply modelled their machines on the requirements of the racing man, not on those of the man who rode simply for pleasure, or of the elderly man who required quite a different thing from the young man or the racing man. There were two kinds of fatigue, muscular and nervous. An elderly man, in fact everyone above 30, very soon got out of breath if he had to make very rapid movements, and consequently there had been a demand for high gears; but many had gone too far in that direction. Elderly people did require a slower speed, which enabled one to pedal properly, but you could not get the slow speed by a high gear without producing an undue strain on the muscles from the extra pedal pressure. The only remedy for this was to lengthen the cranks. In order to satisfy themselves on this point, he and his son, who worked the thing out together, made a series of experiments to find out what was the position at which a man could exert his leg muscles to the

greatest advantage. They actually got inside one of the big testing machines and measured the power of thrust for every position of the leg, measuring from the centre of the thigh joint to the ball of the foot. The maximum thrust was at a point where the leg was much more bent than it possibly could be on a cycle, even if it had 12-inch cranks, so they were satisfied that no one could lose power by bending the leg too much. By actual practice on the road they also found that no one got stiff or tired by bending his leg too much; all stiffness and fatigue of that kind came from too great pedal pressure. They therefore reduced the pedal pressure by increasing the crank length and also by another device. However well a man might pedal, he was practically a single-acting engine; but every engineer knew that if he wanted a light engine he must have a double-action one. By using certain pedal connections, which, however, allowed you to readily free the foot if necessary, they were able to give not only the most effective down-stroke, but also to work on three-fourths of the up-stroke. The result was that they could do a certain amount of work, either hill climbing or against the wind, with very much less maximum pressures on the muscles than with an ordinary bicycle. He never found a hill he could not climb, or a wind he could not face, and he was able to ride 100 miles in seven hours, which he thought was fair proof that there was some advance made by this change of design. It was, however, a radical change, because if you took an ordinary cycle and put these long cranks on to it, in the first place the frame was too short for the cranks to clear the front wheels, and in the next place it would not be strong enough to stand the strain of the extra leverage. Some details had, therefore, to be altered, and the result was a step in advance, which if not comparable to that made by the pneumatic tyre, was yet very considerable. He thought cycle manufacturers had yet a great deal to learn, and did not study the comfort of riders to the extent they should. One spanner which need not weigh more than an ounce, ought to be sufficient for every machine, but they always sent out several, one being an adjustable spanner, which every engineer knew was an abomination. They were also probably the greatest offenders in the matter of having different threads on their screws; they should meet and adopt one standard and stick to it.

Dr. E. B. TURNER said Mr. Starley laid great stress on the pneumatic tyre doing away with fatigue and increasing speed, owing to the way in which it did away with vibration. To a great extent it did reduce vibration, but the real reason why people were able to accomplish long distances with so little fatigue was not only because the vibration was less, but because the pneumatic tyre increased the speed. The consequence was the power exercised in propulsion was less; there was less waste of muscular tissue, and less waste or burned up tissue passed into

the circulation, where its presence created irritation and produced fatigue fever.

Mr. J. PENNELL asked why Mr. Starley had not referred to the American Star machine, which for many years was very successful, and had been copied in many types; he should like to know if there was any chance of such a machine with free pedals and other advantages coming up again. He believed a low form of the Star was also made; the high Star, although very comfortable, was the most dangerous machine ever invented; it was 5 feet high, and if you did not take good care you would be landed on the ground at any moment. He had also expected to hear something about the chainless machine, which they were told not long ago in that room was the best thing made. After hearing that he got one, but he could only say after riding it 300 miles that he had never had such a terrible experience in his life. It went pretty fairly on a level road where he tried it first, but when he came to the hills he was obliged to get off and walk, and before long he put it into the train and he had never ridden it since. A chainless machine might be all right theoretically but practically it was all wrong.

Mr. W. T. SHAW said he should be glad to hear the length of crank Mr. Crompton used, and the gear. The single driving tricycle referred to in the paper was made in Dublin by Carey, and in Coventry by Singer, and he recollected an old gentleman at Singer's in London, who always rode one up to almost last year. The invention of the suspension wheel, the hollow rim, and the indiarubber tyre, were all claimed by the late Mr. Cowper, and he understood the claim was allowed. Singer's also made a dwarf 'Xtraordinary, with a speeded-up gear, but he could not say whether it was before or after Hillman and Herberts', but both types went out on the introduction of the rear-driver.

Sir HENRY WOOD thought that Mr. Pennell had been rather too sweeping in his condemnation of the chainless gear. He also had been fortunate enough to become the possessor of one of the Columbia bicycles, though the machine had been in his possession too short a time for him to form any opinion as to its merits, even if he were qualified, which he certainly was not, to express an expert opinion. But it had been ridden by himself and by his son, and so far as could be judged from a few short rides of twenty and thirty miles, it promised to work quite satisfactorily.

Mr. W. WORBY BEAUMONT said one of the great reasons for the superiority of the long crank which Mr. Crompton used, coupled with the high gear which it enabled him to use, was the slow speed at which the foot travelled. With a short crank and a gear of, say, 63 inches, and a pace of 12 miles an hour, the

rate of reciprocation of the leg was so great that the muscles had not time to receive and act on their instructions to follow the crank round; in fact, many cyclists only gave a push to a comparatively short part of the path described. In Mr. Crompton's case the foot had time to act and to follow the crank round, and with his additional appliance, to even lift it during the back portion of the circle. With a high speed on the crank as required by a low gear, such a continuous pressure was impossible. Mr. Crompton and he accompanied the Automobile Club on their Easter tour, when he had an opportunity of seeing what Mr. Crompton could do. He always reckoned himself a fair hill climber, but he found that Mr. Crompton's longer crank gave him an advantage. Though they did not keep with the motor cars all the way, they managed to reach the end of the journey at the same time, and they could always overhaul them on the hills. No doubt Mr. Crompton invented the application of the compensating motion to traction engines, but it had been done before by Burstall or Hill about 1834, when they made their steam carriage. He did not know who was the real inventor of the suspension wheels but in 1869 his grandfather, Mr. Worby, gave him a pair which he had made in 1848, and before that he believed Lord Dundonald had made a wheel with spokes formed of chain, and possibly someone else had made them even earlier.

Mr. WARNER JONES said some of the early safeties did not steer very well, but in 1889 he invented the curved front fork which was now universally used, and he really believed that had a great deal to do with the success of the dwarf bicycle, as it perfected the steering. He considered it a great mistake of manufacturers to value a machine only by what it could do on the racing path. A bicycle should be a perfect geometrical figure, having a certain sized wheel, a certain wheel base, and a certain slant, which gave the best effect, and all should be in proportion to the height of the rider; if any part were out of proportion there was a loss of power. He did not agree with the long cranks except for a specially hilly country, but the real thing to aim at was an elliptical motion for the foot, which would give the same effect in a different manner. At the present time while the foot was performing a rotary motion the ankle was travelling in an ellipse, whereas it should be the reverse, the ankle motion should be rotary, and that of the pedal an ellipse. There had been an elliptical machine built which gave a good result, but, unfortunately, it was not perfect, the pendulum on which the crank worked being outside the back wheel instead of in the centre. He thought this was a point well deserving the attention of manufacturers.

The CHAIRMAN congratulated Mr. Starley on his exceedingly interesting history of the cycle, which his well known connection with the trade had peculiarly fitted him to give. He remembered being particularly

struck by the introduction of the Rover at a time when there was no defined idea as to what direction the development of the bicycle was going to take, though tricycles of all kinds were then common. When it first came out it was very much disliked by many, and he well remembered the first time it appeared on the Ripley Road, when it was christened the Blondin Donkey. It looked a most extraordinary thing, and he remembered saying to himself that it seemed that at last a machine had been put together that was the ideal of construction, and that it must sweep everything before it. In that opinion he was perfectly right, but he also said another thing which was equally wrong, namely, that the machine would never be ridden without hands except by professed acrobats. He could not believe at that time that it could be ridden with the perfect ease with which it was by any ordinary rider without hands, as his own experience had shewn him. He had been using a machine not suitable to ride with hands off before he took to the Rover, and as soon as he got it he thought he would try what difficulty there really was in riding without hands. He did not go through the dynamical argument which Mr. Sharp had given in his book, but he felt that there was a means of producing a definite stability of balance by a slight swaying motion of the body, by which the frame of the machine would be canted in the desired direction and cause it to turn one way or the other. At any rate he felt that as soon as he tried the experiment for the first time, which was on the wood pavement at Palace Gate, South Kensington, and before getting to the end of the road he found he could go tolerably well. Mr. Starley had said very little about the ladies' bicycle, and it was curious to remark, in connection with it, what a change of fashion there had been the last three years. People who looked upon the bicycle as a low and vulgar thing, who would have considered it altogether *infra dig.* to ride a machine, and almost, to speak to a person on a machine, were now the most violent advocates of the cycle, and this equally applied to the fair sex. There were two points with regard to the ladies' machine on which he might say a word. One question was whether there was any necessity for making machines especially for ladies, and the other was the necessity, or advantage, or disadvantage of curved tubing if a special frame were necessary. His own view on the first point he expressed in a review in *Nature* last summer, of Mr. Sharp's book, and putting it shortly, it was to the effect that it was a great pity that when four or five years ago ladies began to cycle, that they had not the common sense to follow the lead of their sisters in France by adopting a dress which made cycling much more easy and pleasant than it could ever possibly be in skirts. Unfortunately the curse of fashion had interposed. Ladies jumped at the bicycle suddenly without any consideration. If lady cycling had only developed slowly, and people one by one had been persuaded it was a thing worth doing even at a little sacrifice, a suitable dress would

not have been considered impossible but necessary. He remembered that the few fashionable people whom he had the privilege of knowing, when discussing the question of getting a bicycle, used to ask whether it would be necessary to wear "those things." Unfortunately, for the comfort of feminine cycling, the verdict of fashion went forth that "those things" must not be worn; that they must cycle in a kind of garment which would obstruct and interfere with them in every way, a kind of garment the obstructiveness of which man, though much stronger, would never think of enduring. With regard to the second point, he had seen most absurd things written, based on an obvious truth, but leading to an erroneous conclusion. The statement was made that a straight tube was stronger than a curved one, and so no doubt it was with regard to end-to-end tension or compression, but the stresses and strains which came upon the frame of a bicycle were not necessarily confined to those of that nature. The actual frame was not a linked structure. The joints were considerably stiffened, and the nature of the stresses on the frame were of various kinds, and it was quite possible that a curved tube might be more suitable to meet such stresses than a straight one. He was not going to advocate using a curve which should exactly balance all the stresses and strains when the rider was sitting as a deadweight on the machine. Those were only incidental and casual compared to those met with in riding over rough roads and with heavy pedalling, but the argument that a straight tube was necessarily the best under all conditions was fallacious. That being the case, especially in a machine made for ladies, the maker should at any rate consider the convenience of the machine for their use and give them more room for their absurd garments, particularly if they wished it. With regard to the chainless bicycle the American was not the only machine. He would confess that his own views since the introduction of the Acatene, were against the likelihood of that class of machine competing with the chain, but as soon as he saw that the Americans had laid themselves out to produce a chainless bicycle with all the perfection that American tool makers displayed, he had some doubt whether perhaps a chainless machine might not actually become a fair rival of the chain. The chain was one of those structures which would run well with moderately good work and would run somehow with very bad work. It ran excellently with the very best work. On the other hand, bevel gearing must be made with a degree of accuracy which was altogether out of proportion to anything necessary for the purpose of getting a good result with chain gearing. The material must be the best and cut with the greatest accuracy; the teeth could not be cut with a milling cutter, they must be planed out, and the machine must not only be in perfect adjustment, but must remain in absolutely perfect adjustment. If it would not keep its adjustment it would have no future, but if it would remain

in adjustment with the ordinary strains of fair riding then it would not be wise to say that such a machine was quite ridiculous, and not worthy of consideration. He had hoped to have had a trial of a Columbia machine, but owing to a side slip, not from his machine, but owing to a slight accident when he was walking, he had been prevented. The long-crank machine of Mr. Crompton he was most anxious to try. He did not think it was going to abolish the shorter crank, but he did feel that the reasons given for its use had a very great deal in them. He was not a strong rider, but with a certain amount of experience had become a fairly good hill rider, and this he attributed entirely to the method of pedalling which every experienced rider knew, but which beginners, especially if they were strong, did not think much about. The great object was to keep a gentle pressure on the pedal as far round the whole stroke as possible, and it was quite evident that a long crank, with a slower rotary action, gave one more opportunity of practising excellent pedalling than you had with the higher rotary motion and the short crank.

Mr. STARLEY, in reply, said he could not say whether the unicycle, which had been shown on the screen, had ever been used. The fact was the slide got in by mistake. Knowing that a sociable bicycle had recently been introduced, he wanted to show Wharman's old balancing sociable, but by some means a mistake had been made. With regard to the invention of the balancing gear. His own experience was that there were very few things invented once and once only. When you had an idea and went to a patent agent to make a search, it almost invariably turned out that if you did not find the exact invention you found that some mechanical motion had been made for something of a very similar character. Almost all the things ever brought out were invented not only two or three times, but perhaps twenty or more, and it was not always fair to give the first inventor the credit for whatever came after. He happened to be out riding with his uncle when he first thought of the balance gear, and he was quite sure that it was not until he found the front wheel going from side to side from the unevenness of the pedalling, that he thought of any such action. At the time he patented it, he did not think he ever knew of the invention Mr. Crompton had spoken of. With regard to the chainless machine, he was afraid there was very little chance of anything being produced which would take the place of the chain, for there was no part of the machine which had proved so thoroughly efficient. If it had not been for its great efficiency it would have been covered up years ago. Still, if anything could be found which would give an all-round action, equal to the chain, manufacturers would not be slow to adopt it. It was quite a mistake to suppose that they were indifferent to any new ideas which came out. He should endeavour to take the hint thrown out by Mr. Crompton with regard to sending out so many spanners.

The CHAIRMAN then proposed a vote of thanks to Mr. Starley. It was carried unanimously.

MEETINGS OF THE SOCIETY.

FOREIGN AND COLONIAL SECTION.

Tuesday afternoon, at 4.30 o'clock :—

MAY 24.—"The Goldfields of British Columbia and the Klondyke." By W. HAMILTON MERRITT. Sir CHARLES MALCOLM KENNEDY, K.C.M.G. C.B., will preside.

CANTOR LECTURES.

Monday May 23, at 8 p.m. :—

PROF. CHARLES A. CARUS WILSON, M.A., M.Inst.E.E., Professor of Electrical Engineering, McGill University, Montreal. "Electric Traction." Lecture IV.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, MAY 23 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. (Cantor Lectures.) Prof. Carus Wilson, "Electric Traction." (Lecture IV.) Geographical, University of London, Burlington-gardens, W., 3 p.m. Annual Meeting.

TUESDAY, MAY 24 ... SOCIETY OF ARTS, John-street, Adelphi, W.C., 4½ p.m. (Foreign and Colonial Section.) Mr. Hamilton Merritt, "The Goldfields of British Columbia and the Klondyke."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. S. R. Gardiner, "The Historical Development of Modern Europe." (Lecture IV.)

Photographic, 12, Hanover-square, W., 8 p.m.

Anthropological, 3, Hanover-square, W., 8½ p.m.

United Service Institution, Whitehall, S.W., 3½ p.m. Capt. A. H. Terry, "Transport in the Field."

WEDNESDAY, MAY 25...British Astronomical, University College, W.C., 5 p.m.

THURSDAY, MAY 26...Royal, Burlington-house, W., 4½ p.m.

Antiquaries, Burlington-house, W., 8½ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Lord Rayleigh, "Heat." (Lecture III.)

Electrical Engineers (at the HOUSE OF THE SOCIETY OF ARTS), 8 p.m. Prof. Carus Wilson, "The Design of Electric Railway Motors for Rapid Acceleration."

FRIDAY, MAY 27...Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. General Sir Andrew Clarke, "Sir Stamford Raffles and the Malay States."

East India Association, Westminster Town-hall, S.W., 4 p.m. Mr. Archibald Colquhoun, "Rail-Connection of India and China."

Clinical, 20, Hanover-square, W., 8½ p.m. Annual Meeting.

Physical, Chemical Society's Rooms, Burlington-house, W., 5 p.m. 1. Messrs. Edser and Butler, "A Simple Interference Method of Reducing Prismatic Spectra." 2. Mr. Campbell Swinton, "Some Further Experiments on the Circulation of the Residual Gaseous Matter in Crookes' Tubes."

SATURDAY, MAY 28...Royal Institution, Albemarle-street, 3 p.m. Mr. J. A. Thomson, "The Biology of Spring." (Lecture II.)

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FRIDAY, MAY 27, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.**ALBERT MEDAL.**

The Albert Medal for the present year has been awarded, with the approval of H.R.H. the Prince of Wales, the President of the Society, to Professor Robert Wilhelm Bunsen, M.D., For.Memb.R.S., "in recognition of his numerous and most valuable applications of Chemistry and Physics to the Arts and to Manufactures."

CONVERSAZIONE..

The Society's *Conversazione* will take place at the Natural History Museum, Cromwell-road, S.W. (by permission of the Trustees of the British Museum), on Wednesday, 22nd June. The reception by Major-General Sir Owen Tudor Burne, G.C.I.E., K.C.S.I., Chairman, and the other members of the Council will commence at 9 p.m.

The following portions of the Museum will be open:—On the Ground Floor—the Central Hall, British Saloon, and Bird Gallery; on the First Floor—the East and West Corridors, and the Lecture Room.

A selection of music will be performed by the Band of the Royal Marine Light Infantry in the Central Hall, and by the Red Hungarian Band in the Bird Gallery, commencing at 9 o'clock.

Each member is entitled to a card for himself (which will not be transferable), and a card for a lady. In addition to this, a limited number of tickets will be sold to members of the Society, or to persons introduced by a member, at the price of 5s. each, if purchased before the date of the *Conversazione*. On that day the price will be raised to 7s. 6d.

These tickets will only be supplied to persons presenting members' vouchers (which can be obtained from the Secretary) or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman, and must be signed by the member applying for it.

Light refreshments (tea, coffee, ices, claret cup, &c.) will be supplied.

The entrance to the Museum is in the Cromwell-road, carriages must enter the grounds by the east gate and leave by the west gate. The cards must be given up on entering the Museum.

Visitors arriving or leaving by either of the Metropolitan Railways will be allowed the use of the District Company's Subway, which leads from the South Kensington Railway Station direct into the grounds of the Museum.

Fuller particulars as to the musical and other arrangements will be given in the Programmes which will be distributed on the evening.

CANTOR LECTURES.

On Monday evening, 23rd inst., Professor CHARLES A. CARUS WILSON, M.A., M.Inst.E.E., delivered the fourth and last lecture of his course on "Electric Traction."

Mr. JOSEPH G. GORDON (Chairman) proposed a vote of thanks to the lecturer for his valuable course of lectures, which was carried unanimously.

The lectures will be printed in the *Journal* during the summer recess.

FOREIGN AND COLONIAL SECTION.

Tuesday afternoon, May 24, Sir CHARLES MALCOLM KENNEDY, K.C.M.G., C.B., in the chair.

The paper read was "The Goldfields of British Columbia and the Klondyke." By W. HAMILTON MERRITT.

The paper and report of the discussion will be published in a future number of the *Journal*.

Proceedings of the Society.

APPLIED ART SECTION.

Tuesday afternoon, May 10, 1898: Dr. RICHARD GARNETT, C.B., in the chair.

The paper read was—

THE LIFE-WORK OF WILLIAM MORRIS.

By F. S. ELLIS.

Though six years have gone by, it seems but yesterday since I made one of a large audience assembled in this hall, which listened, with earnest attention and eager interest to an address, on the subject of "The Woodcuts of Gothic Books," by the great man concerning whose wonderful artistic and literary career I have undertaken to speak this afternoon, according to the best of my ability. But I believe I am justified in calling his career not only wonderful, but also in applying to it the often misused term unique, for casting back one's eye over the glorious roll of English poets, which among them, I would ask you, besides William Morris has been so gifted, as not only to enrich the world with a full tide of song, but also to make the age in which he lived an epoch in decorative art?

Little did I suppose, as I listened to his well chosen words on the occasion I have mentioned, that it would ever fall to my lot to speak of him as belonging to the past, for he was four years my junior, and until his last illness attacked him, seemed always possessed of so much life, vigour and activity, as might be expected to carry him to extreme old age. Alas! that it is otherwise, for his value in the world was far greater than that of a whole heap of other men, including myself.

No one who has eyes to see, intelligence to understand, and wit to judge, can doubt that in the loss of William Morris we have reason to mourn a genius of such magnitude as towered aloft even among the men of marked ability, brilliant faculties, and great attainments, who were contemporary with him, like a landmark in a wide plain. His death has left a blank that none of us can reasonably hope to see filled in our time. But though he was my junior in the mere reckoning of years, from the first day that I made his acquaintance I recognised clearly in how great a degree he was my

senior in intellectual capacity and acquired knowledge. For more than 30 years I was accustomed to regard him as a teacher and a master, and you must therefore not expect from me anything by way of criticism on his life-work other than hearty appreciation, admiration, love and wonder.

Yet it must not be supposed that he was one of those who desire to exact from their associates entire agreement on all subjects, or who thrust their views and opinions, whether upon art or other matters, dogmatically upon their neighbours: he was, on the contrary, always most willing to listen to objections, and to explain, and consider a question from various points of view, unless he found his interlocutor to degenerate into ignorant nonsense or self-conceit, when he would close the discussion quickly enough.

In thinking over his marvellous personality, I should not, though his versatility was wonderful, be inclined to describe him as a versatile man, for that term is usually applied to one who can do a great many things fairly well, but for the most part imperfectly. That was not the case with William Morris. Many things he assuredly could do, but he never rested till he was fully master of that which he undertook, and could do it thoroughly well—I will not say perfectly, for he would himself have counted the word "perfection" inadmissible in art; as Ruskin has admirably and forcibly pointed out, "perfection usually means a loss of strength and degeneration into littleness," and a phrase that was constantly on Morris's lips was that, according to the French proverb, "Better is the enemy of good."

But he was a many-sided man; to work at whatever he set his hand to till he was so entirely master of the subject that he was able to instruct others; to know the history, the secret, the why and wherefore of everything he engaged in, was his great characteristic. Yet those who knew him best will bear me out, when I say that never was any man more entirely free from petty conceit and self-consequence. Though fully conscious of his own power and inherent ability; though, I believe, gratified to feel assured that he was looked up to by his fellows as a man of genius; he was, nevertheless, one of the most simple-minded, yea, one of the most humble-minded, among men. His consciousness of power and knowledge in such things as he gave his mind to, raised him above the pettiness of conceit; while his clear conception of the limitations of his own, and of all human knowledge,

engendered in him that humility which is a special note of truly great minds.

It was my good fortune to make the acquaintance of William Morris as long ago as 1864, when "Jason" was as yet unpublished, and he was unknown in literature and art beyond a narrow circle of friends. One of his grand qualities was faithfulness. I believe I may say with confidence, that throughout his whole career he never lost a friend, except by the hand of death. The friends of his youth were the friends of his maturity; alas! that it cannot be said of his old age, for he was but 62 when he died, and no one ever thought of Morris as an old man. Even when the stroke of sickness fell upon him, and until within a few weeks of his death, his mind was as fresh and vigorous, his touch as certain, his fecundity of invention as wonderful, and his imagination not only as brilliant as in youth, but infinitely more so, growing brighter, richer, and more varied and powerful, as the years rolled on, and until the very end was reached.

It is needless for me to recite to an audience such as I have the honour of addressing this afternoon, any particulars concerning the biography of William Morris. They have been given, pretty much as I could relate them, in many of the magazines and newspapers during the last eighteen months, and in Mr. Aymer Vallance's important and excellent work, entitled, "The Art of William Morris." For a full and exhaustive biography, we must look forward to the book promised by Mr. Mackail in the course of next year, with confident anticipation that it will be well worthy its subject.

Suffice it to say, that William Morris was born on the 24th of March, 1834, the eldest son of a man engaged in financial business in the city of London, who, by the accident of a fortunate investment, made a short time before he was cut off in the very prime of life, left his widow in such circumstances as enabled her to give all her children a handsome fortune as they came of age. This was certainly a circumstance as happy as it was remarkable, in that it opened possibilities to the future artist of carrying into effect his views on art at an early age, which might otherwise have been seriously retarded, or even never have had the opportunity of expansion and fulfilment. That the surroundings of the boy and youth were by no means calculated to awaken a love of art will be readily understood and allowed by all who are conversant with what was in vogue in prosperous middle-class life

during the first half of the present century. But it would seem that a love of the beautiful, and a sense of what was ugly, abhorrent and vulgar, was intuitive in William Morris's mind. I remember him speaking many a time of the Exhibition of 1851, at which all the world was struck with unbounded admiration, and telling how, as a youth of 17, he declined to see anything more wonderful in it than that it was "wonderfully ugly," and, sitting himself down on a seat, steadily refused to go over the building with the rest of his family.

At Marlborough College, which he always spoke of with the greatest dislike and repugnance, he would not join in the ordinary games or sports, but found delight in rambling over the country-side on holidays, exploring its archæology and enjoying the scenery. His walks about the Wiltshire downs he used to talk of enthusiastically to the end of his days. I have also heard him describe how, in the shorter intervals of leisure, he would employ himself in making nets, a token of the spirit of the handicraftsman, which afterwards found such ample and glorious development. His abhorrence of Marlborough arose largely from the recollection that his teachers there taught him nothing whatever, so that one of the aptest scholars that ever lived had to be put under a coach before he was equal to matriculating at Oxford. It is needless to make more than a passing remark on a circumstance which had assuredly a most important effect upon his life-work. I refer to the extraordinary fact of his life-long friend, Edward Burne-Jones, matriculating on the same day, and shortly afterwards forming his acquaintance. Nor is it necessary to enquire into the causes that led both these students to renounce the clerical career that had been marked out for them. An inspiration fell on these youths, each of them coming from family and surroundings as little likely to prompt them to art or poetry, as were those of Chaucer, of Shakespeare, of Turner, or of Ruskin, but the wind bloweth where it listeth. The influence of Ruskin with the promoters of the Oxford Union, caused Dante Gabriel Rossetti to obtain a commission at Oxford, and here was the flame at which the ready match of enthusiasm was kindled. The Oxford, of forty or fifty years since, was a spot much more calculated to foster and encourage the spirit of mediævalism, which was an integral part of Morris's nature, than it is under its present aspect. The whole place wore a much more venerable and anti-

quarian air than it does at the present time. In his later years, Morris would earnestly deplore the ruthless spirit of change which had robbed Oxford of the charm it once had for him, and it was with difficulty he could be persuaded to go thither, even though his residence at Kelmscott brought him so close upon its borders. He used to speak with enthusiasm of the delight he experienced, as an undergraduate, in turning over some of the magnificent manuscripts preserved in the Bodleian, especially the "Romance of Alexander," and a 13th century "Apocalypse."

I think it may fairly be said that the life-work of William Morris, as given to the world, began in his student days with the founding of the "Oxford and Cambridge Magazine." From the way he mentions this publication, I infer that Mr. Vallance was unaware that Morris bore the sole cost of its production. Under such circumstances it is remarkable that it should have lasted through a year. I should think its doing so was due only to Morris's hatred of anything incomplete. The twelve months rounded it off so to speak. Mr. Vallance mentions, as though it were a fact, that Morris kept a copy of this book under lock and key by reason of the great store he set upon it, a statement that must be due to some misunderstanding, for he certainly set no store whatever by the volume, and kept nothing under lock and key, even his watch-key was usually astray. The same writer discusses the question of reprinting such articles as Morris wrote for the magazine. Of that I can only say that I should regard it as a ghoulish proceeding, and a dishonour to the author's memory, who again and again forbade their reproduction. I am happy in thinking that there are yet some years before anyone dare reprint these articles without permission, and that before that time arrives I shall, in all likelihood, be beyond the knowledge of such matters. Having emancipated himself from the prospect of a clerical career, what could be more natural than that he should look to the practice of architecture as a profession, and with that idea article himself to the man who was in those days looked upon as an oracle in that branch of art? But a year's experience in Mr. Street's office, and the clearer perception of what architecture should be, more especially that Gothic architecture, to the love of which his soul was wedded, caused him to see the

impossibility, under present conditions, of attaining to and carrying out his ideas, and he therefore sacrificed the remaining term of his articles, and turned his attention to other matters.

That he might with success have followed the profession of a painter is demonstrated by the excellent portrait of his wife, painted before his marriage in 1859, which has come to light during the past year, after being for a long period supposed to be lost altogether. But I believe he felt that as a painter he would be overshadowed by the surpassing genius of his most intimate friend: his own saying was that he could not make his figures move. That he did not persevere in his studies in that direction was assuredly a great gain to the world at large, for, whatever distinction he might have gained as a painter and a poet, it is obviously impossible that he could in that case have achieved the great work as a handicraftsman and designer for which all those who have any eye for beauty are so largely in his debt. The year 1858 is marked as an important one in his life by the publication of his first volume of poems. It is no wonder, seeing how entirely original was the note struck by Morris, that the book was not very heartily received by the public. It would have been a marvel had it been otherwise. It was offered to several publishers, and among others to Mr. J. W. Parker, proprietor of "Fraser's Magazine," a person considerably esteemed in those days, as I well remember, for a man of taste and a fine critic. He declined to publish the volume, and after it appeared, had—as appears from a letter which has lately come to light—no better idea of the value of the verse than that "nineteen-twentieths of it was he most obscure, watery, mystical, affected, stuff possible."

The genuine and earnest mediævalism of the author was altogether lost on Mr. Parker. That the volume was not an immediate success is not, as I have said, to be wondered at, for no book that is out of harmony with the spirit of the age can be expected to succeed until interest in the movement of it is awakened. Two young men, who in their maturity are still among us (Dr. Garnett, who has honoured me by his presence in the chair to-day, and Mr. Joseph Knight), raised their voices, through the press, in appreciation of the new singer; but that the volume had not a very rapid sale was evidenced by the fact that some seven years later I bought from Messrs. Bell and Daldy the copies that then remained unsold, amount-

ing, if I remember rightly, to some thirty or forty. But that the "Defence of Guenevere" met with no greater appreciation on its first appearance is, I think, easily accounted for; unless the reader has some knowledge of the "Romance of King Arthur," and the "Chronicles of Froissart," and, indeed, of the mediæval spirit generally, it must be mere affectation to pretend to understand and enjoy the poems in Morris's first publication; as well might an oriental, who had never heard of London, affect to enjoy the humours of "Pickwick." A good deal has been said about printing other poems written about the same date, which the author preferred to leave unpublished. I am happy in knowing that the one person whose authority would be needed for the publication of them, has decided against it, and will, I trust, make such provision as shall prevent them being put into print at any future period. He was too capable a critic of his own work for there to be any justification for publishing that which he desired to consign to oblivion.

Architecture and painting abandoned as the occupations of his life, Morris's practical mind addressed itself to the task of showing that it was possible, while perforce shutting one's eyes to the exterior hideousness of ordinary houses, to do something towards making the interiors more tasteful and beautiful than they had been for many a long year—reversing, in fact, the old saying concerning the cup and the platter.

The house designed for him by his lifelong friend, Mr. Philip Webb, was perhaps, if we except some attempts in the pseudo-Gothic style, the first in the England of the 19th century to be arranged and decorated in a departure from the hideousness of deal doors painted and grained to look like oak or maple, staircases covered with mustard-coloured paper, and squared in blocks to imitate some sort of marble that never existed, hangings usually of a dull heavy rep, and, in the wealthier houses, stuffs equally ugly, if more costly, varied in summer by preposterous sham lace, black horsehair chairs, ponderous yellow mahogany sideboards, and flock wall-papers. Those who are old enough to remember what it was all like, will, I think, bear me out, when I say, that though our dwellings of to-day may not all of them be models of good taste, they are certainly better than they were in what we may call the age of anti-macassars and Berlin wool-work. It was at this time that Morris set himself to understand the method of ancient

needlework and embroidery. To make himself completely master of how it was done, he obtained some pieces of ancient work, carefully took them to pieces, thread by thread, and thus made himself completely acquainted with the mode of construction, and then fell to designing patterns and figures, and worked the first piece with his own hands. The result was a series of noble needlework figures, for panels in the Upton-house. I well remember with what surprise and delight it was that I first beheld these pieces of handicraft at Queen-square, and what a revelation of the possibilities of modern needlework it was to me. It seemed to carry one back to another world. The series, as originally designed, was never completed; four of the panels are now, I believe, in the possession of the Earl of Carlisle, and four or five others are preserved elsewhere.

It speaks volumes for the vigour and hopefulness of the man that he ventured to set forth, so to speak, single-handed, on the task of awakening people to a sense of the hideousness that surrounded them, and the possibility of something more artistic and beautiful; for although he associated himself with other men of genius and ability, from whom he received most valuable aid and support, it was, in truth, the remnant of his fortune that furnished the means of beginning the work which he and his friends undertook. How he threw himself earnestly into the project, is witnessed by the fact that he left his pleasant house at Upton, and came to live in the smoke of central London, that he might give himself wholly to it. It is needless for me to go into the history of the establishment of the firm of Morris, Marshall, Faulkner and Co., which in outline is an oft-told tale, and will doubtless be given at full in the forthcoming biography.

As he has told us himself, in his lecture, entitled, "Making the best of it," delivered before the Trades Guild of Learning, at Birmingham, in 1880, it was useless to suppose that any quick and sudden change could be made for the bettering of the outward forms of the houses which most of us, by no choice of our own, are compelled to inhabit, and the only thing to do therefore, was to provide the means of making the interior surroundings, more or less beautiful, by wholesome and pleasing decoration of the walls to begin with, and then by designing tasteful stuffs for curtains and hangings, and furniture less cumbersome and unsightly, both in form and material, than was commonly procurable at that period. Both wall-papers and textile fabrics were at first very simple,

but not the less admirable therefor, but of later years they grew in many instances to be more rich and costly, according to the demand that arose for them. How thoroughly Morris understood his aims and his work, is manifest in every line of his invaluable lectures, entitled, "Hopes and Fears for Art," delivered at Birmingham, London, and Nottingham, between 1878 and 1881. What can be more to the purpose than these words on wall decoration? "Every line must have a distinct idea in it; some beautiful piece of nature must have pressed itself on our notice so forcibly that we are quite full of it, and can, by submitting ourselves to the rules of art, express our pleasure to others, and give them some of the keen delight that we ourselves have felt. If we cannot do this in some measure, our paper design will not be worth much: it will be but a makeshift expedient for covering a wall with something or other, and if we really care about art we shall not put up with something or other, but shall choose honest white-wash instead, on which sun and shadow play so pleasantly, if only our room be well planned, and well shaped, and look kindly on us." How completely do these words reveal to us the real secret of Morris's success as a designer, namely: the perfect grasp that he had of his subject, and the spirit of love and enjoyment with which he bent to his work, so that it was a real pleasure to him, destitute of toil and pain. Morris's designs for wall-papers amounted to fifty entirely distinct patterns, which are worked in no less than 237 different colourings, every one of them arranged and directed by himself with that marvellous and unerring instinct for harmony of colour, which was one of his most wonderful gifts, and one of his most remarkable characteristics. So great is the difference made by the interchange of colours, that the same pattern, to any but an expert and practised eye, would appear to be altogether distinct. This is no mere opinion of my own, but a fact that is proved by everyday experience. Then he produced forty-two designs for printed cottons in 159 variations of colour, 39 designs for woven materials set out in 164 colourings, and a very large number of elaborate patterns for carpets and rugs of different textures, sizes, and varying methods of manufacture.

In the Birmingham lecture, from which I have already quoted, the author is at the pains to give most valuable hints for the arrangement and decoration of a house, which are well worth the study of all who desire to

make the interior decent, whatever the exterior may be, for which, in truth, usually, the occupant is not accountable. One part of the exterior he does make useful suggestions for, namely, the setting out of the garden, wherein assuredly as much taste may be shown as in the decoration of the house, and it is moreover much more easy of execution, and less costly, for once set going in the right way, it will in a great measure care for itself, and richly repay the attention bestowed upon it.

I do not hesitate to say that but for the life work of William Morris, the amelioration of commonplace ugliness, which may be traced in thousand of houses, would never have come about, but things must inevitably have gone from bad to worse. No doubt a large part of the world persists and will persist in preferring ugliness to beauty—so much the worse for it. Sir W. B. Richmond, in his eloquent address to the students of the Royal Academy, has well said: "The fine arts are a necessity to a small public; the handicraftsman is a necessity to all: both are desirable, one is essential." I think one might gloss this saying by the remark, that the handicraftsman of taste and judgment ought to be especially considered necessary to the possessor of works of pictorial fine art, for what I would ask you is more discordant or distressing to the eye, I might say, indeed, what is more ludicrous than to behold grand pictures hung in a room or gallery hideous in colour, amid ostentatious but tasteless surroundings?

At an early period of his artistic career, Morris gave much attention to the manufacture of stained glass. No one who takes an interest in the subject can doubt that he exercised a very beneficial influence over it in respect of tone and colour, for which he had such an unerring eye. He had, moreover, the extraordinary advantage, over all other practitioners in the art, of being able to command the willing and friendly services, in design, of Rossetti and Ford Madox Brown, and specially of Burne-Jones. This alone would suffice to give the work he carried out a most important and notable distinction. Yet I believe that he regarded his work in this supremely difficult art with less satisfaction than any other to which he devoted himself. He has in his masterly and most admirable article on the subject, in "Chambers's Cyclopædia," shown us how fully and thoroughly he knew what he was about. Of later years he recognised how great a mistake it was to put new glass into ancient Gothic traceries,

savouring in truth of the worst form of "restoration," and steadily refused to join in such work. It may not be, as he has asserted strenuously in the article mentioned above, a "lost" art, but it is assuredly a dead art—as dead as the men who carried it to perfection in the 13th and 14th centuries. Its spirit was the spirit of the Middle Ages, and that cannot live in the 19th century, though we may drag forth the lifeless shadow of it. He was painfully aware of the monstrous incongruity of the modern practice of putting a dozen or more styles of glass into one building. The absurdity is hardly less, and the irritation to the spectator would be scarcely greater, if a dozen different architects were commissioned to design the body of a church, employing styles varying from the Byzantine of the 7th century to the Renaissance of Inigo Jones, in its various parts and divisions, the whole being mere imitative work,—a Norman choir, a Byzantine nave, south transept early English, north transept Renaissance, and so on. Yet that is what is commonly done with stained glass. What think you would have been the effect of the Kelmscott Press Chaucer had it been illustrated by a dozen different artists, in as many different styles? If anyone desires to test for himself the truth of what I have advanced I would recommend an inspection of Wells Cathedral by way of example. The glorious east window, full of indescribable beauty, remains as a witness against the monstrous crudities and platitudes that surround it on every side to the utter degradation of a noble branch of ancient art. I hope it will not be supposed, when I protest against the absurdity of putting different styles of architecture or glass into one building, that I am ignorant or unappreciative of the value and interest of historical accretion in a building, which is a vastly different thing from feeble imitative confusion and contradiction.

Since writing the foregoing passage, I have had the pleasure of reading Mr. Lewis Day's most valuable and interesting paper on the "Making of a Stained Glass Window." He tells us therein how the modern science of chemistry has enabled artists to come at all the component parts of ancient stained glass. In like manner a chemist can analyse the finest wine, and set out all its component parts, but putting them together will not make the wine, sun and soil and atmosphere are left out of account, and so in like manner when we have every material and method that a mediæval

glass painter used, we lack the simple unquestioning belief and unhesitating assertion, which imparted life and spirit to the work of men in the middle ages—the body we may have, but the soul will be wanting—it is but imitative work.

Though I suppose the Applied Arts Section does not include poetry, it is impossible to speak of the life-work of William Morris without mentioning his poetry and other literary work.

It is true, on the other hand, that I can speak of no part of his work, or of his doings, without speaking of his poetry, for verily his whole life was a poem, in its highest sense; his aspiration for the good and beautiful in art, his love of and entire devotion to nature, his abounding hatred of cruelty, injustice, robbery and wrong, his whole-hearted identification of himself with the cause of the oppressed, his recklessness of the consequences to himself in his endeavour to carry out his ideals, his contempt for worldly honours; all this made his life a poem in itself, and as such, I feel confident it will come to be understood, when the mists that envelop us are cleared away, and he and his work are viewed by unbiassed eyes in clear perspective.

But to speak specially of his literary work, when we call to mind that his metrical writings amount, at a rough computation, to more than 150,000 lines, and add to them those wonderful prose poems which were the product of his later years, we can scarcely fail to be altogether astounded, not only at the fecundity, but also at the untiring industry of the great genius who gave to the world this glorious treasure of poetry of the highest order amidst the distractions of commercial business, the study of a dozen different handicrafts, the production of innumerable designs for wall-papers, tiles, textile fabrics and carpets, the direction of a printing-press, and the carrying on of a political propaganda. Yet I venture to aver that none of his verse bears signs of haste or carelessness. I have in my possession a large mass of his original MSS., which bear witness to the care with which he would try his wings until he got fairly into flight; he would freely correct, alter, and rewrite, till he had satisfied himself with his work: that done and fairly copied, he rarely made any further alteration, and I should doubt if any poet returned cleaner proofs to the printers. His revision of succeeding editions was of the slightest, rarely did he alter a single word. But this did not

arise from indolence, but from his faculty of seizing the aptest word or most felicitous phrase with little effort, and once adopted, he was ultimately satisfied with it. Morris's wealth of diction can scarcely fail to strike any reader of his works who knows what that phrase means. So completely was he master of his mother tongue, that he had not an English dictionary among his many books, until, about a year before his death, he was induced from curiosity to buy "Skeat's Etymological Dictionary." Words seemed to well up in his mind as he wrote, as water bubbles from a spring. So great was his facility of composition on occasions, that when the tide once flowed it seemed to rush on irresistibly. It is notably on record that, when the story of Jason had taken firm hold of his imagination, he wrote continuously in one day, beginning at 4 a.m., 750 lines. In turning over some of his MSS. lately, I came on a memorandum made by him on the foot of a page, "310 lines after 10 p.m."

It is no unusual thing to hear people affect the opinion that quantity comes before quality in Morris's poetry, an allegation that I do not hesitate to traverse. I never yet put one of these cavillers through his facings, as to how much he knew of the work he was carping at, that I did not succeed in running him down to the confession that his knowledge of the poet he criticised, was confined to reviews and extracts. Some one, as rash as he was ignorant, lately ventured to say in print somewhere, that the author himself held but lightly by his work of "The Earthly Paradise." Never was a more unfounded statement. Had there been any ground for it, the production of the sumptuous edition of the book printed at the Kelmscott Press would assuredly not have been one of the author's cares during the last months of his life. The great northern epic of "Sigurd the Volsung" must, I think, be looked upon as Morris's supreme poetic triumph, and he certainly regarded it in that light himself. It is not only the masterly way in which he has evolved the grand and stately story from the ancient legend, but the pathos, passion, and nobility thrown into it, make the reader feel that here he is truly face to face with one of the world's great poets. The splendid roll of the rhythm, which never for a moment flags, and the masterly manner in which the language is handled, cause one now and again to pause in admiration, and to wonder at the unexpectedness, yet perfect aptitude of the phraseology; the words seem to spring forth, as it were, by magic, and

every line palpitates with vigour, life, and light. Morris, in this great poem, seems to wield the English language as Sigurd wielded the Light of the Branstock, the gift of Odin, every word and sentence coming home with irresistible power and might. When the book was published, in 1878, though the grandeur of it was acknowledged and recognised by most of the reviewers of the day, the critic, whoever he may have been, who at that moment was powerful at the *Times* office, put a studied insult upon it by coupling it with a volume of verse by a poetaster which had appeared about the same period. It mattered not: the book was, and will remain, a glorious contribution to the main stream of

"Poesy's unfailing river,
Which through Albion winds for ever,"

Where, in the whole range of English verse, shall we light upon nobler numbers than in the pathetic description of Sigmund delivering the dead body of his son, Sinfjotli, to Odin, after he had been poisoned by his stepmother Borg-hild?

"Then he lifted him up from the hall floor and bore him on his breast,
And men who saw Sinfjotli deemed his heart had gotten rest,
And his eyes were no more dreadful. Forth fared the Volsung child
With Signy's son through the doorway; and the wind was great and wild,
And the moon rode high in the heavens, and whiles it shone out bright,
And whiles the clouds drew over. So went he through the night,
Until the dwellings of man folk were a long while left behind.
Then came he unto the thicket and the houses of the wind,
And the feet of the hoary mountains, and the dwellings of the deer,
And the heaths without a shepherd, and the houseless dales and drear.
Then lo, a mighty water, a rushing flood and wide,
And no ferry for the shipless; so he went along its side,
As a man that seeketh somewhat: but it widened toward the sea,
And the moon sank down in the west, and he went o'er a desert lea.
But lo, in that dusk ere the dawning a glimmering over the flood
And the sound of the cleaving of waters, and Sigmund the Volsung stood
By the edge of the swirling eddy, and a white-sailed boat he saw,
And its keel ran light on the strand with the last of the dying flaw.
But therein was a man most mighty, grey-clad like the mountain-cloud,
One-eyed and seeming ancient, and he spake and hailed him aloud:
'Now whither away King Sigmund, for thou farest far to-night?'
Spake the King: 'I would cross this water, for my life hath lost its light,
And mayhap there be deeds for a king to be found on the further shore.'

'My senders,' quoth the shipman, 'bade me waft a great king o'er,
 So set thy burden a ship-board, for the night's face looks towards day.'
 So betwixt the earth and the water his son did Sigmund lay;
 But lo, when he fain would follow, there was neither ship nor man,
 Nor aught but his empty bosom beside that water wan,
 That whitened by little and little as the night's face looked to the day.
 So he stood a long while gazing and then turned and gat him away;
 And ere the sun of the noon-tide across the meadows shone
 Sigmund the King of the Volsungs was set in his father's throne,
 And he hearkened and doomed and portioned, and did all the deeds of a king.
 So the autumn waned and perished, and the winter brought the spring''.

Never did any poet write more genuinely and spontaneously from inspiration, without giving one moment's consideration to the question whether what he thought of writing would be likely to find acceptance with the public, or, in other words, whether it would sell. He wrote for art's sake, and for art's sake only.

I well remember that in early days, some thirty years ago that is, he used to be curious as to how his verse would be received, but of later years he was wisely impervious to hostile criticism, though he was always grateful for intelligent appreciation. He was, in truth, an able critic of his own work, and was happily confident of future fame.

Inwoven as it were with Morris's life-work, was a happy circumstance which for 25 years helped to give to it colour, vigour, and happiness, and contributed in no small measure, I venture to think, to the value and beauty of all he set his hand to. This was the acquisition, as a dwelling, of the ancient manor-house at Kelmscott, in Oxfordshire. Scarce could the wand of a magician have called into being a home more suited to his tastes and sympathies, than this secluded spot, close to the stream whose gently-sloping uplands, flower-bearing banks, willowy nooks, rush or reed-grown reaches, clear shallows, and swirling eddies, are so exquisitely pictured in his poems. The grey-weathered walls of the stone-built gabled house, surrounded by an old garden with a moss-grown orchard, and a meadow-close hard by, made it the very place of retreat he had longed for. He once told me that when he first went to look at it he found that it exactly resembled a house he once had a vision of in a dream. To escape to Kelmscott from the smoke and turmoil of London when he had any special

work, literary or graphic, on hand, was of the greatest benefit to its successful accomplishment, or to go thither and throw off work altogether for a short season occasionally, was the most grateful refreshment to his mind.

But even while his spirit was filled with the great epic of the North, his eyes had been pasturing on the rich colour and inimitable designs of the East. So far as my memory serves me, it was about 1875 that his mind was specially fired by the magnificence of the ancient oriental carpets which were just then imported in large quantities. He bought a great number of choice examples and set himself to study, not only the scheme of design and colour, but also the method of manufacture. His study of design, whether in this or anything else, did not mean crude and ineffective copying of original patterns, but as in literature his style is no servile following of ancient form, but an assimilation of so much as is good and valuable in it, so did he assimilate the manner of the ancient traditional patterns of the East, and thence produce thoroughly original and harmonious work, graceful in line and beautiful in colour. It was no light matter to begin such an undertaking. There was no warehouse, whither he could go to buy such wools as he needed, ready to hand; he must dye them himself, and with an enterprise and unwearied determination rarely equalled—never certainly by one who was also a great master in song—he set himself to learn the craft and practice of dyeing, first carrying it on in the cellars of his dwelling-house at Queen-square, and subsequently at the works which he established at Merton.

Having thoroughly mastered the art himself, he soon set others to work, with a result that had but one fault, namely, that the work he produced was too absolutely good and perfect to meet with general acceptance in the more costly forms, but nevertheless the Buller's Wood and the Peterhouse carpets, and many another, will for long years to come testify to the success and excellence of the manufacture, while the simpler webs have been distributed far and wide to the brightening of many hundreds of homes. Another great project which he carried out to its fulfilment with perfect success, as you may see by the splendid examples exhibited this afternoon, was the restoration of the manufacture of tapestry as a fine art in England, where in old days it had rivalled the work of our neighbours over-sea, but had latterly died out

altogether. To make himself a master of this art, he set up a loom in his bedroom at Hammersmith, and there worked a panel with his own hands. The difference between Morris's work and the most costly kind of tapestry made elsewhere is not, I believe, so much technical as æsthetical. The art has unfortunately been diverted from its true decorative character, to the copying of pictures which do not properly lend themselves to such reproduction, and were never intended for it.

Morris worked from designs made specially for the purpose, for the most part. Those who have had the good fortune to see the magnificent hangings in the dining-hall of Mr. Darcy's house at Stanmore, representing the "Quest of the Holy Grail," will understand how great a triumph has been achieved, where the designs of Sir E. Burne-Jones are worthily worked out under the great craftsman's personal superintendence. The piece of the "Four Seasons," which by the kindness of the authorities of the Science and Art Department of South Kensington, is exhibited here to-day, was designed by Morris himself, and I think will be allowed to be no mean witness to his power of drawing the human figure when he was put to it by necessity, as happened on this occasion.

Among the many arts to which he applied himself with notable success, I must not omit the mention of one which has scarcely been heard of beyond the immediate circle of his private friends though he bestowed much time and attention upon it and attained to great skill in its practice. I allude to the truly mediæval art of calligraphy. This, like many other of his labours would have been with an ordinary man an exclusive and absorbing life-study, not so with Morris, he studied it at odd moments, and pursued it as a pastime, to fill up a few odd hours as it were. Numerous volumes are in existence to bear witness to the mastery he attained in this beautiful art, many of them being enriched with original decorative designs. Among the specimens of his calligraphic skill are several translations of the Icelandic Sagas, two of which are exhibited here to-day by the kind consent of Lady Burne-Jones, but his masterpieces were Fitzgerald's translation of the "Quatrains of Omar Khayyam," and the works of Horace and Virgil, the latter unfortunately never completed.

I should do Morris's memory a great wrong if I should to omit all mention of the noble stand he made against the destruction of ancient

works of art at the hands of the ruthless restorer and the commercial wrecker. As a foremost founder of the Society for the Protection of Ancient Buildings, in company with Mr. Thackeray Turner and others, he did work that entitles him to the gratitude of every man and woman who has any true love for the glory of our ancestors. Nothing but absence from London ever kept him from the weekly Thursday evening meetings of the society, and often would he return to town from a great distance, at extreme inconvenience to himself, that he might attend to what he looked upon as one of his most important objects in life. Innumerable were the letters he wrote on the subject, and great was his grief when, as but too often happened, the destroyers were deaf to all appeals. Nevertheless, the good work done by this modest but energetic society can hardly be over-rated, and I would earnestly urge on every one in this assembly, who has any love for ancient architecture, and any real reverence for the memory of William Morris, that there can be no better way of showing it than by becoming a member of the Society for the Protection of Ancient Buildings at the trifling subscription of 10s. 6d. per annum.

While considering Morris's life-work, it is impossible to pass over one subject which for about fifteen years absorbed a vast deal of his time and attention. Though it may appear on the surface to have no direct relation to the study, practice, and teaching of art, he firmly believed that it went to the root of the whole matter, inasmuch as he held that there could be no good craftsmanship while the craftsman was in a state of degradation. I refer, of course, to the Socialist movement, into which from about 1881 he threw himself, heart and soul. When once he became convinced of the justice of the cause, he cast aside all considerations of personal taste, ease, and comfort, doing violence, as I well know, to his own feelings and predilections, and forcing himself to personal work and labour that was absolutely distasteful to him.

I must confess that it amazed me to see how earnest he was in his belief that some great change in the constitution of society could be wrought suddenly, and by direct means. Never did any man give himself to a cause with purer unselfishness and more hearty devotion. Personally, he had everything to lose (as the world counts such matters), and nothing to gain. Fame he already possessed, and notoriety he genuinely and utterly scorned. For some years he bore the

whole cost of printing a weekly paper, which never approached within a long distance of paying its expenses. He was not overburdened with ready money at the time, and even sold his cherished books to provide funds. But he spent not only money, but a large share of his time in writing about current politics, which were altogether hateful to him. Yet, unlike those men who quarrel with all who do not share their own enthusiasms, I never knew him attempt to thrust his opinions on those who differed from him, and I greatly doubt if he lost a single one of his old friends through his generous espousal of an unpopular cause. In his later years, though he did not alter his opinions, it appeared to me that he was satisfied that any chance of forcing on a sudden change was altogether hopeless. Who is there but must admire the ardour with which he worked? not merely by giving moral and pecuniary support to the cause he had adopted, but in leaving his comfortable home and pleasant literary and artistic occupation, to go forth early in the morning to speak at the dock gates and street corners, attending innumerable evening meetings in localities that were anything but grateful to his æsthetic tastes, and travelling thousands of miles to the Midlands, the North of England and Scotland to speak at public assemblies, and all with no hope of other reward than that which arose from the consciousness of doing work which he firmly believed to be for the benefit of those who most needed his help.

But the neglect of his business, which this disinterested political activity made inevitable, had a far different result than that which might have been expected. Being left to the able management of the two gentlemen whom he latterly took into partnership, the business flourished far more than it is likely it would have done otherwise, and so led to the great undertaking which, in my eyes at least, was the crowning work of his life, namely, the establishment of the now famous Kelmscott Press, and, moreover, afforded him the means of collecting the magnificent library of illuminated manuscripts and early printed books which was the delight and solace of his last years. The ordinary 19th century printing and book illustration had long been a thorn in his side. I well remember how, some 25 years ago, he took up a volume printed by Aldus about 1490, in his earliest and best manner, and exclaimed as he turned over the pages, "Ah! I wish I could get my books printed like that." But to hope for the fulfilment of

his ideal of typography by applying to any of the ordinary commercial printing offices would have been as futile as to attempt to get wall-papers to his taste from the ordinary decorator: there was but one way—to do the thing himself. But the starting of a press and the casting of founts of type are no slight matters, and had not money been coming in pretty freely from the business, under his partners' able management, I do not suppose that "The Golden Legend," the "Chaucer," or other noble monuments of artistic typography, would ever have seen the light. As it had been with his previous undertakings, so was it with this. The whole scheme bristled with difficulties and hindrances at the outset, which would have deterred a man of less resource and determination from going on with it. But his knowledge of caligraphy and early typography, coupled with the able assistance of Mr. Emery Walker, rendered him independent of the ordinary means of starting a press, and for the first time since printing has been practised in England, types were designed and cast which are at once useful and artistic. Morris has not unfrequently been complimented, by writers who knew no better, on being the best English printer since Caxton; the fact being that, although we honour Caxton's name as the introducer of typography into England, and as a writer of sterling English, it may safely be said of him that he was the worst printer of the 15th century. His types were rude, his woodcuts beneath contempt, and his presses of the weakest, while his texts were faulty beyond measure. The founder of the Kelmscott Press happily lived to see the completion of the book upon which, of all others, he had set his heart, viz., the monumental edition of the works of his master, Geoffrey Chaucer. By a happy conjunction of circumstances, three important editions of the great poet have been given to the world in forestalment of the 500th anniversary of his death, now so closely upon us; Prof. Skeat's Clarendon Press edition and the Globe edition being monuments of textual labour and scholarship, and the Kelmscott Press edition being, I do not hesitate to say, for typography, ornament and illustrations combined, the grandest book that has issued from the press since the invention of typography. It was but three short months before the end came that Mr. Douglas Cockerell arrived at Folkestone, where the dying poet was then staying, with the first completed copy of the Chaucer, bound from his own design. The title page had been his last great work, and he

turned over the pages with evident gratification, weak and feeble as he then was.

How many grand books might have issued from the Kelmscott Press had the master's life been prolonged, it is impossible to say, but three books he had specially in his mind, to wit, Shakespeare, the English Bible, and Froissart's "Chronicles;" for the last-mentioned he had already designed some borders. Alas! these three glories of the English language are, in all likelihood, destined to wait long ere they appear in such guise as Morris purposed to bestow upon them.

To sum up, then, for forty long years were the teeming brain and the deft hands of this indefatigable worker busy for the benefit of his fellow men; from the day, we may say, when he projected the "Oxford and Cambridge Magazine," in 1856—when the world seems to have been almost young as we look back upon it—till within a few days of his death in 1896. And how truly marvellous has been that work, how many homes have been made more cheerful and happier by the brightness and beauty his genius has bestowed upon them; what love of antiquity has his teaching awakened and kept alive; how many ancient monuments have been saved from destruction by his efforts; what new life has he given to the art of design, if men will but have the wit to learn the lessons he has afforded them: what a storehouse of delight and pleasure has he laid open to us in his immortal verse and those magnificent prose poems—his romances—and what a glorious halo has he shed round him by the nobility of his character.

In all the intimate relationship of business and private friendship that I had with this great man, extending over a period of more than thirty years, I never knew him to give countenance to an action of which any man might be ashamed, and the shadow of a falsehood was as foreign to his lips as is snow to midsummer: to attempt to get the advantage over his fellow man was a thing that never for one moment entered his mind. He has in truth left us by his life-work a glorious heritage which all men may enjoy, and truly may it be said of him, that "He being dead yet speaketh."

DISCUSSION.

The CHAIRMAN, in opening the discussion, said he did not feel competent to enter on the question of that side of Morris's work which must chiefly interest

the Society, viz., what he did as an artist and handicraftsman, but he might make one remark on his literary activity. A great deal was said about the inartistic and unpoetical character of the present day, some of it rather unjustly, he thought; but at any rate it was remarkable that in this age only, as far as he was aware, had men been found who united great literary abilities with the highest decorative powers. Putting aside the very few metrical productions of Michael Angelo, he did not think that in the history of the world any man had arisen who was qualified to stand in the first rank both as a poet and an artist, until Dante Gabriel Rossetti. It could not be said that William Morris stood as a painter in the same rank as Rossetti; but if one looked to his decorative work in artistic design and construction, he presented a phenomenon not less remarkable, and in these men were combined for the first time in the history of the world the poetic and artistic faculties, in such perfection in each case, that one knew not which to place first. As arts and manufactures concerned that Society more than letters, he would not detain them with any observations on the literary question, but hoped they would be favoured with some further observations on Morris as a designer.

MR. LEWIS F. DAY said, in response to the Chairman, that they had all come to hear what Mr. Ellis had to say about a man whom they honoured as a man and admired as an artist. He would not attempt any appreciation of Morris; they all knew him; it might all be summed up by saying he was Morris. Possibly he did not always quite do himself justice in what he said, but conveyed by his frank and fearless utterance a wrong impression of what he meant. He was not quite sure whether, in regard to stained glass, Mr. Ellis was quoting William Morris, or expressing his own opinion, when he pronounced this an art in which it was impossible to succeed in these days. It was quite true that the past was past, but, for his own part, he thought Morris succeeded quite as well in stained glass as in tapestry—in both cases with the aid of his friend, Sir Edward Burne-Jones. He personally did not see the inferiority of his glass, in fact of the two he preferred it; he saw no reason for saying that you could not take what there was to be got from old glass, quite as happily as you could take old Sicilian silks or mediæval tapestries as your starting point, which Morris did, and yet succeeded always in being himself—an epoch-making designer. No one who knew Morris but must recognise that he was *facile princeps* as a designer; but if he had ever said what Mr. Ellis attributed to him with regard to glass, he, the speaker, would have quarrelled with him, as he often had done in a friendly way. One of the privileges of knowing Morris was that you could quarrel with him—as you did; but quarrel with him as you might you knew him always to be the finest fellow, and the greatest decorative artist, of his day.

Dr. FURNIVALL said he could not say much about the art of William Morris. He remembered on his first visit to the house at Bexley Heath, Morris showed him a cabinet he had been painting, which was not quite finished, but he had made great use of two colours which he (Dr. Furnivall) hated above everything—one a light yellow, and, the other, London mud. He ventured to object to these colours, but the only reply was: "Don't be a d— fool." Morris generally set you down in that way if you did not agree with him. For all that, he had a most genuine admiration for Morris, whom he had known as long, though not so intimately, as had Mr. Ellis, each being busily engaged in his own pursuits. They came more together over the printing of the Chaucer, which arose from the publications of the Chaucer Society, which he (Dr. Furnivall) established, and of the Early English Text Society, of which Mr. Wheatley was the original honorary secretary. It had given him the greatest pleasure to hear this paper by Mr. Ellis, who knew Morris so well; who lived with him, fished with him, worked with him, edited for him, believed in him, and was with him until his death. In fact, he and Mr. Emery Walker were to Morris the most affectionate of brothers; and it was a delight to every one who knew them, to think of how they helped Morris in all his work, and made him as happy as they could during the last years of his life. All their friends must respect and love them for their affection, love, and devotion to Morris. There were one or two things only in the paper with which he did not quite agree. One was as to the question of bringing to light the early work of a man which he had not published himself. He had talked this over with Tennyson and Browning, and differed from them as he did from Mr. Ellis about it. His feeling was, that when a man had attained to such eminence, students who followed him and wanted to know how he got there, were justified in seeking to know the process by which he rose. When you facsimiled a poem of Shelley's, and showed a dozen or a score of corrections before it was finished, there was no dishonour to Shelley's memory. It was not the vulgar curiosity which was so much pandered to in the newspapers, but a desire to understand how the man rose, and to watch his rise. It was a reverent curiosity, and a desire to learn how to improve. Then, with regard to phonology and knowing how to pronounce the old English tongue, he believed the late Alexander J. Ellis, Dr. Sweet, and others could reproduce the sounds of the 13th and 14th century English from historical data, and that it was not unintelligible gibberish when you got accustomed to it, but pleasant and easy to follow. Mr. Ellis had referred to Professor Skeat's "Chaucer," to his own edition printed at the Kelmiscott Press, and to the excellent Globe edition which had since been issued. He hoped there would be a good deal more controversy over Chaucer's text. He much regretted that Morris did not live to produce the Shakespeare and Froissart. It was delightful to hear

such a tribute to Morris from so true and long-abiding friend as Mr. Ellis; it was the second lecture he had heard by him, the first being more on the poet's literary work, and for both he was very grateful to him; his enthusiasm was as creditable to him as it was honouring to Morris. He was sure that if William Morris knew what was going on he would be gratified to think that his old friend had risen up and borne such eloquent testimony to his character and work.

Mr. COBDEN SANDERSON said he was very glad to have been present to hear this noble tribute by Mr. Ellis to the memory of his old and dear friend. He had told them how he had touched one craft after another and given it new life, and he was glad that he had not forgotten one subject which some perhaps were desirous to ignore—William Morris's contribution to the Socialism of to-day. Morris began in early life seeking to make things about him beautiful, things about himself and his house; then he passed on to making the environment of other men's lives beautiful, and in that work he was engaged to the close of his life; but as his work went on, and as he became more and more familiar with life, he sought to make life itself beautiful, and at last that became the chief subject of his thought, and he sought in Socialism the means to make life beautiful. To his mind that was his great distinguishing feature as an artist and a poet. It was too seldom that poets interested themselves in the actual life of the world; they were engaged, and well engaged, in making an imaginary world beautiful, and artists also were engaged, too exclusively perhaps, in the abstract conception of beauty. Morris, while in sympathy with both was infinitely more in sympathy with life itself, he believed that was his distinctive feature, and the one to which perhaps posterity would pay the greatest honour. He was a very dear friend of his, and they were intimately connected in the binding of some of his books; but he was happy to say that whilst he bound the Chaucers, or some of them, William Morris himself designed the cover, so that he launched his great book on the world as he himself desired it to appear.

Mr. EMERY WALKER said he should like to make one practical suggestion, viz., that the Society of Arts or some public body should acquire while they were still to be had a complete set of Morris's patterns in their various colourings. As time went on they would get lost unless the collection were made at once.

Mr. METFORD WARNER said he should like to bear his testimony to William Morris's truthfulness and care in everything he undertook. The branch of his industry with which he was connected was that of the manufacture of wall papers, and it might be supposed that Mr. Morris would take less interest in it than in those manufactures where more expensive materials

were used, but he could testify that he took the greatest personal interest in it, and allowed nothing to pass until he was quite satisfied that it was right both in colour and design; he remembered a case where he had an entire set of expensive blocks put aside because he was not satisfied with the design. He had not enjoyed the personal friendship of Mr. Morris as some others had done, but he had been closely connected with him in business for over 25 years, and he had also been thrown into connection with many of those who did not appreciate Mr. Morris. By such people he had sometimes heard him called a humbug, but he had always assured them that such a word was less applicable to him than to anyone he knew. Whatever he did, he did from his heart, and he was very glad to have had this opportunity of saying publicly what he had often said privately.

Sir HENRY TRUEMAN WOOD said it might be interesting to mention a fact, known to but few present, but one which he was sure all would like to know, viz., that if William Morris had lived a short time longer he would have been recommended to H.R.H. the President for the award of the Albert Medal of the Society. In mentioning this he was betraying an official secret, but he felt that the circumstances of the case excused him, and that the Council would not object to his doing so. The real reason why the medal had never been awarded to William Morris was simply that he was looked upon as a comparatively young man with many years of life before him, and on several occasions his claims were postponed to those of much older men, who, in the natural course of life, could not, it was thought, have much more time before them. By the irony of fate, all those distinguished men were left, and William Morris had passed away. They knew how little he thought of all social distinctions, but he could not but think that he would have liked his name to have been placed on the list which contained such names as those of Faraday, Wheatstone, Bessemer, Siemens, and many others—men to whose labours and investigations the present condition of our civilisation was in great part due. The list of Albert medallists, unfortunately, contained very few workers in art, and that was due to the fact that it was not sufficient for a man to have done good work, but his work must have exercised great influence, and they would all agree that that was the predominant characteristic of Morris.

The CHAIRMAN, in proposing a vote of thanks to Mr. Ellis for his paper, observed that it was peculiarly interesting from the close relation in which Mr. Ellis throughout the greater part of Morris's life stood to him, not merely as a warm and intimate personal friend, but as a coadjutor. It was not always the case that the relations of author and publisher were distinguished by a remarkable

amount of cordiality, but when they did agree their unanimity was wonderful. He really thought, in all seriousness, that the friendship of Mr. Morris and Mr. Ellis would go down to posterity along with the many interesting literary friendships which had done honour to the republic of letters. Mr. Ellis was not merely a publisher; he had himself benefited English literature by some very acceptable works, of which he might mention particularly that gigantic task, the Concordance to the works of Shelley. When they were reminded of the great amount of excellent literary work which had been given to the world by William Morris, he could not but think of those who had helped, and he certainly doubted if he would have given so much had it not been for the appreciation which he got from that very quarter, whence appreciation was most valuable and encouraging to a young author, an enthusiastic publisher. Although Morris always insisted on art being distinct from commercialism, they had learned even from Mr. Ellis, that, after all, letters and commerce must be to a certain extent united, and they had heard that in all probability they would never have had the Kelmscott Press and its typographical treasures but for the commercial success of William Morris's manufactures, due to the commercial zeal, energy, and tact of his partners. They had heard of his antipathy to the Great Exhibition of 1851—in which he must say he did not at all agree with him—but, if he was determined to dislike it, he showed a wise discretion in refusing to see it. That was a matter of taste; but, as a matter of fact, he believed that but for the Exhibition, and the great impulse then given to artistic manufactures, it was very doubtful whether the firm of Morris and Co. would have ever existed at all. They could not get rid of the interdependence and connection of various pursuits. As things fell more into line, harmony and proportion, no doubt the figure of William Morris, which now looked so Titanic and thoroughly original, so combative and iconoclastic, would become more blended, and harmonize better with the general progress of literature and art. He might say, in conclusion, that the department of prints and drawings at the British Museum received a short time ago a bequest of the wood blocks used by William Morris in the Kelmscott Press, and he hoped they would be arranged in a few days in the King's Library, together with some of the books they were used to produce.

The vote of thanks having been carried unanimously,

Mr. ELLIS, in reply, said he could not hope that all his remarks would be exactly accepted by everyone, and he was quite prepared to find that Mr. Lewis Day differed from him with regard to stained glass. He hoped some day he might have the opportunity of discussing the matter with him fully, but he did not think he should alter his opinion.

Miscellaneous.

ANTWERP CONGRESS ON COMMERCIAL EDUCATION.*

An International Congress on Commercial Education met this year at Antwerp, under the auspices of the Club of Former Students belonging to the Higher Commercial Institute of that town.

The various foreign Governments were well represented. The English delegates far outnumbered the others. The Government sent Captain Abney, C.B., F.R.S., Director of the Science Division of the Department of Science and Art; Mr. T. King, Senior Chief Inspector of Schools under the Education Department; Mr. G. R. Redgrave, Chief Senior Inspector in the Department of Science and Art; Mr. R. L. Morant, Assistant Director of Special Enquiries in the Education Department; Mr. W. Woodall, M.P., member of the late Commission on Technical Education. The Congress was very well attended, the number of its adherents amounting to over 250.

The Congress was opened by Monsieur Nyssen, Ministry of Industry, who had on his right the military governor of Antwerp, and the Burgomaster on his left. After a few words of welcome from the minister, M. Strauss, the president of the organising committee, made a most interesting inaugural speech. As a strong partisan of international co-operation and an ardent believer in free trade, he declared that one man's gain was not necessarily another man's loss, but that it was to the benefit of each individual nation that all should grow rich together. Ignorance spelt misery, knowledge was power, but knowledge must be given in an organised fashion. Otherwise, one might, like America, spend £40,000,000 a year on education and not get an adequate return for the outlay. The speaker raised a laugh by saying the English Merchandise Act had been a splendid advertisement for foreign goods. In conclusion, he said commerce has been revolutionised in the last forty years. It had become so scientific that a careful training in commercial subjects was essential to those who went into business to-day.

Monsieur Siegfried wished the Congress success in the name of France, after which Monsieur Strauss was nominated president, while Captain Abney and Mr. Redgrave were nominated vice-presidents for England. The Congress then proceeded on an official visit to the Burgomaster at the Town-hall. The Burgomaster, in speaking of the sacrifices that Antwerp made on behalf of education, said that out of a budget of £160,000 a year, £100,000 was devoted to education.

In the afternoon, the first subject set down for discussion was the utility of a complete commercial education. M. Heinzmann Savino protested against

premature specialisation. At the request of Monsieur Siegfried, Mr. Brereton read in French a short paper, in which he gave a *résumé* of an inquiry he had made on "Higher Commercial Education in France." In presenting his conclusions, which were of a favourable nature, he offered them as an object-lesson to other nations who have shown themselves backward in this matter, and especially to England. Monsieur Siegfried expressed himself strongly in favour of higher commercial education, he was less certain of the value of purely commercial teaching in secondary and primary schools. This led to the President proposing to pass to the second question, which discussed the extent to which commercial instruction should enter into primary education. Herr Hirschhorn, of Mannheim, said that in his school pupils in their last year took up shorthand and type-writing, with good results. Mr. Barlow, of London, declared that people in England were opposed to any specialisation in primary schools; he was, however, contradicted by Mr. Nixon, who cited Manchester as a town in which early specialisation was to be found. M. Bonsoy, of the Antwerp Industrial School, complained that geography was neglected. M. Fleury, of Paris, pleaded for a fuller recognition of the teaching of geography. Dr. Stegmann, of Brunswick, dilated on the advantages derived from a system of obligatory education, continued up to the age of 18, in the evening classes. Mr. Redgrave laid down that commercial instruction should come after primary. According to the director of the Duijesschool at Christiania, commercial specialisation had been a failure in that establishment. Monsieur Siegfried summed up the debate in saying that the verdict of the Congress seemed almost unanimous on the point of leaving primary instruction entirely free and general.

The whole of the second day was devoted to examining the question as to how far commercial instruction should enter into secondary education. Vainly Monsieur Siegfried tried to direct the discussion to the merits or demerits of the commercial intermediate schools, such as exist in Germany and France, but it drifted into a desultory debate on secondary education in general, and to what extent it was, or ought to become, commercial in tendency. M. Strauss considered commercial notions more indispensable to the average man than notions on literature. These sentiments found little favour with the Congress. The opposite theme was the subject of an excellent paper by Mr. Fabian Ware, who declared himself the partisan of education in its true sense "of the harmonious development of the mental and moral man." He regarded the German Realschule as the proper model to follow. Commercial specialisation should not begin till after 16. Dr. Stegmann informed the Congress there were 250 commercial schools in Germany, of which the Saxon were the best. M. Vernon complained of the undue preponderance in the Conference of pedagogues over business men. M. Pascolato said in Italy the technical schools were much appreciated by those

* By Cloudesley S. H. Brereton, M.A. Cantab, L. ès L. Paris.

entering commerce. In France, according to M. Beugnot, of Paris, both the State and the "free" educational bodies are in favour of intermediate commercial schools.

In the afternoon, Mr. Graham, of Wakefield, gave an account of commercial education in the West Riding of Yorkshire. Mr. J. Brigg, M.P., confirmed his statement. Mr. Nixon, of Manchester, explained what the neighbouring county of Lancashire was doing. Details of the Belgian system of commercial education for women were given by Monsieur Sobry. The Norwegian delegate regretted the lack of special technical instruction in Norway—a school of pisciculture does, however, exist. Herr Hirschhorn protested against undue commercial specialisation in secondary education. Mr. Jack Sherman said that, in America, a boy of 16, after receiving a general education, could enter a high school for learning book-keeping, or a business college if he wished to learn the practical side of commerce, but, unfortunately, the teaching of modern languages was very defective. M. Cuisset spoke of the good results in modern languages obtained by the evening classes of the "polyglot" clubs in Belgium. Once more Monsieur Siegfried summed up the debate. Secondary education ought to remain general, but special schools of commerce may exist in the large towns, as in France and Germany, to train the "privates" and "sous officiers" of the army of commerce.

On Saturday morning, before a sadly thinned audience, Mr. Morant, in a powerful speech, begged the representatives of other countries to give their English *confrères* the full benefit of their experiences in higher commercial education. The English delegates were more or less favourably disposed towards the idea, but there were many points of detail on which they required information. Should the school be attached to a university, or unattached? Should the teachers of trade subjects be merchants or pedagogues? Should special courses of study be introduced for the different professions? This straightforward and vigorous speech met with much applause. The answers seemed to be rather in favour of leaving the school as free as possible, and of giving the teaching of certain subjects in the curriculum to men who had had a business training. On the other point the Congress was divided. M. Heinzmann-Savino gave a clear exposition of the Antwerp Institute, and insisted on the formation of a colonial section. M. Piérard was in favour of creating a course of "shipping" in the Antwerp school. Only 4 per cent. of Belgian merchandise was carried in Belgian bottoms. M. Pascolato described the school of Venice founded on the Antwerp model; the curriculum took from three to five years, according to the subjects taken. It was impossible to shorten the curriculum without impairing the efficiency of the teaching.

In the afternoon the Hungarian delegate gave an interesting description of Hungarian schools. There are 84 lower schools of commerce, and 27 upper,

along with 18 technical schools. He warned the Congress against the danger of too great uniformity.

Proceedings were brought to a close by a vote of thanks to the Chairman, proposed by M. Pascolato. In the course of his remarks the Italian delegate invited the Congress to come next year to Venice. The "venue" for the international Congress for 1900 is already fixed. It will necessarily be, like all other international congresses and meetings, at the "world's Mecca," Paris.

MEETINGS FOR THE ENSUING WEEK.

TUESDAY, MAY 31... International Association for the Protection of Industrial Property (at the House of the SOCIETY OF ARTS), 11 a.m. Congress. Reading of papers and discussions.

Royal Institution, Albemarle-street, W., 3 p.m. Prof. S. H. Butcher, "Literary Criticism in Greece." (Lecture I.)

WEDNESDAY, JUNE 1... International Association for the Protection of Industrial Property (at the House of the SOCIETY OF ARTS), 10½ a.m. Congress. Reading of papers and discussions.

United Service Institution, Whitehall, S.W., 3 p.m. Rev. W. K. Bedford, "First Siege of Rhodes, 1480."

Archæological Association, 32, Sackville-street, W., 8 p.m.

Obstetrical, 20, Hanover-square, W., 8 p.m.

THURSDAY, JUNE 2... International Association for the Protection of Industrial Property (at the House of the SOCIETY OF ARTS), 10½ a.m. Congress. Reading of papers and discussions.

United Service Institution, Whitehall, S.W., 3 p.m. Dr. J. Macdonell, "Recent Changes in the Rights of Duties of Belligent and Neutrals according to International Law."

Linnean, Burlington-house, W., 8 p.m. 1. Prof. St. George Mivart, "Notes on some Lories." 2. Mr. E. J. Salmon, "A Revision of the genus *Symblespharis*." 3. Surg.-Capt. H. A. Cummins, "The Food of the Uropoda."

Chemical, Burlington-house, W., 8 p.m. Messrs. H. J. H. Fenton and Mildred Gostling, "The Action of Ether on Organic Acids and on Carbohydrates in presence of Hydrogen Bromide."

Royal Institution, Albemarle-street, W., 3 p.m. Dr. E. E. Klein, "Modern Methods and their Achievements in Bacteriology." (Lecture I.)

FRIDAY, JUNE 3... Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Prof. W. M. Flinders Petrie, "The Development of the Tomb in Egypt."

Geologists' Association, University College, W.C., 8 p.m.

Philological, University College, W.C., 8 p.m.

Quekett Microscopical Club, 20, Hanover-square, W.C., 8 p.m.

SATURDAY, JUNE 4... Royal Institution, Albemarle-street W., 3 p.m. Dr. R. Caton, "The Temples and Ritual of Asklepios at Epidamur and Athens." (Lecture I.)

ERRATUM.—In the last number of the *Journal* (p. 601) Mr. Starley's initials were incorrectly printed after the title of his paper as W. K. instead of J. K.

Journal of the Society of Arts.

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FRIDAY, JUNE 3, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.

CONVERSAZIONE.

The Society's *Conversazione* will take place at the Natural History Museum, Cromwell-road, S.W. (by permission of the Trustees of the British Museum), on Wednesday, 22nd June. The reception by Major-General Sir Owen Tudor Burne, G.C.I.E., K.C.S.I., Chairman, and the other members of the Council will commence at 9 p.m.

The following portions of the Museum will be open:—On the Ground Floor—the Central Hall, British Saloon, and Bird Gallery; on the First Floor—the East and West Corridors.

A selection of music will be performed by the Band of the Royal Marine Light Infantry in the Central Hall, and by the Red Hungarian Band in the Bird Gallery, commencing at 9 o'clock.

Each member is entitled to a card for himself (which will not be transferable), and a card for a lady. In addition to this, a limited number of tickets will be sold to members of the Society, or to persons introduced by a member, at the price of 5s. each, if purchased before the date of the *Conversazione*. On that day the price will be raised to 7s. 6d.

These tickets will only be supplied to persons presenting members' vouchers (which can be obtained from the Secretary) or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman, and must be signed by the member applying for it.

Light refreshments (tea, coffee, ices, claret cup, &c.) will be supplied.

The entrance to the Museum is in the Cromwell-road, carriages must enter the grounds by the east gate and leave by the west gate. The cards must be given up on entering the Museum.

Visitors arriving or leaving by either of the Metropolitan Railways will be allowed the use of the District Company's Subway, which leads from the South Kensington Railway Station direct into the grounds of the Museum.

Fuller particulars as to the musical and other arrangements will be given in the Programmes which will be distributed on the evening.

EXAMINATIONS.

The results of the Examinations held at the end of last March are now in hand, and an advance copy will be sent to each centre of examination in the course of next week.

The dates for the Examinations in 1899 will be Monday, Tuesday, Wednesday, and Thursday, March 13th, 14th, 15th, and 16th.

CANTOR LECTURES ON GUTTA PERCHA.

A few extra copies of the Appendixes to Dr. Obach's Cantor lectures on "Gutta Percha" have been printed. These consist of some additional tables, &c., which were not printed in the *Journal*. A copy will be sent, on application, to any member of the Society who desires to bind it up with his volume of the *Journal*.

Proceedings of the Society.

INDIAN SECTION.

Thursday afternoon, May 19, 1898; HENRY M. STANLEY, M.P., in the chair.

The paper read was—

COLONIES AND CHARTERED COMPANIES.

BY SIR ALFRED C. LYALL, G.C.I.E., K.C.B.,
Member of the Council of India.

I have joined together colonies and companies as the subject of my address to you to-day because they are two forms of association that have sprung from the same root, and have always been more or less connected in their

development. Almost all our original colonies in North America were chartered companies; and the style and substance of the charters granted in the 16th century by Elizabeth differ very little from the charters granted in the 19th century by Victoria. When, about twelve years ago, the French Government desired from their Ambassador in London a report on the constitution of the great English companies formed for taking up lands in Africa and elsewhere, M. Waddington replied:—"The clauses in the English charters of to-day are exactly those which are to be found in the charters of the Middle Ages." The history of these associations shows how much could be done by private effort, when that effort is judiciously backed by the State—that is, when private enterprise receives public sanction. There are some things which a Government cannot do officially, and which are best accomplished when the people take the lead, while the State lends its support, remaining in the background until it is required to interfere. *Colonisation* is certainly one of those things. *Commerce* is another; and the system of companies has been largely employed both in the foundation of our colonies and in the spread of our foreign commerce. It has also been used with great success as an instrument of conquest, but this was because the companies soon found it necessary to occupy territory in order to secure their trade.

When I speak of companies, I mean the banding together of men who subscribe their money for the work of private adventure in distant lands, and who for that purpose receive from their Government a charter, investing them with certain self-governing powers, with the right to make laws and ordinances, to make treaties with the natives with whom they have to deal, to acquire territory, and sometimes to monopolise the trade with certain countries. All the earliest English companies were founded upon a desire to secure the profits of trade. So far as I can make out, the first associations of merchants for foreign trade were developed out of the old English trade guilds that were formed for regulating local industries. They were companies of merchant adventurers for conducting, under the King's charter, the exchange of goods between England and the Continent, principally with Holland and Germany—their headquarters were at home, and they had privileged settlements in the cities abroad. Afterwards, as our trade began to cross the ocean, came the rich and powerful chartered companies, who

established themselves in Asia, Africa, and America. And since commerce is older with our nation than colonisation beyond sea, because men went out to trade with distant lands long before they went out to settle; so the Chartered Mercantile Association is the oldest form of the chartered company. The chartered association for colonising purposes came later; but in both cases the substance of charter was the same. In both cases, also, one main object was to open out fresh markets, whether by trading settlements on the sea coast, as in Asia and Africa, or by developing wild and unexplored tracts, as in North America.

The first attempts, therefore, of Englishmen to push their trade beyond Europe into non-Christian lands, were made by the means and under the form of a chartered company. What was it that sent Englishmen roving abroad in the 16th century? I think that a few very broad historical reasons may be given. In the first place we have to remember that for three centuries after the Norman Conquest (in 1066) England was a Continental power; she had very great possessions in France. The first Plantagenet kings ruled over at least a third part of what was afterwards the French kingdom; and it is often now forgotten that for 300 years Bordeaux, with all the surrounding country, far inland, was an English province. So long as England and most of Western France were under one rulership, the two coasts and the commerce between them were virtually under the same Government; and, for a hundred years, our French wars provided ample outlet for the adventurous spirit of Englishmen. By the year 1450, however, we had lost all our French possessions, except Calais, which we kept for one hundred years, and the Channel Islands, which we still hold, or—as the Jersey men say—which still hold England. After 1450 there began a period, I may put it roughly at about 100 years, when the English were confined strictly to their own country, which was distracted by civil wars up to the end of the 15th century. Throughout this period, Scotland was an independent kingdom—in Ireland the crown's authority was for the most part nominal. Queen Elizabeth's real dominion was over no more than England and Wales. The frontier of the British Empire is now in Asia, Africa, and America; 300 years ago it was on the Scottish border. Our little wars now go on in South Africa and beyond the Himalayas; in Elizabeth's time they were waged beyond Berwick and Carlisle. We are now pushing up the Nile and Niger rivers in

Africa, up the Indus and the Irrawaddy rivers in Asia; in Elizabeth's time it needed an armed expedition to cross the Tweed, or else we had a foray among the wild folk in Ulster and Kerry. But all through the 16th century the English people were growing in wealth and power under the strong rule of Tudor kings, and they were beginning to find England too small for them to live in, and so during the reign of our great Queen Elizabeth the English took to distant commerce and the founding of colonies. America had been discovered, full of gold and silver; the Portuguese had shown us the way to the East Indies round the Cape.

Before Vasco da Gama rounded the Cape the commerce between Europe and Asia had been in the hands of the Mediterranean cities, Alexandria, Constantinople, Venice, Genoa; but when the long sea route was discovered, it passed to the nations on the Atlantic seaboard, and when the discovery of America forced the bolder mariners to strike out westward across the wide ocean, instead of coasting about the narrow seas, a great revolution in shipbuilding took place. Spain and Portugal were first in the field. The Pope had divided the whole of the non-Christian world between the Spanish and Portuguese kings, allotting, roughly, all America to Spain, and nearly all the East Indies to Portugal, an arrangement which did not suit us at all. So in the 16th century, when the English and Dutch had quarrelled with Spain and with the Pope, and turned good Protestants, both nations began to push eastward and westward, seeking their fortunes in the East and West Indies, in Asia and America. It was essential to success, in the first place, to break the immense naval power of Spain, for there is no trading to be done on the sea in the face of hostile naval supremacy, and this was done by the destruction of the Spanish Armada in 1588. The second thing was to form companies strong enough to defend themselves along the shores and in the ports of the far-off countries whither we went to trade, where a sharp struggle for valuable commerce was going on. And so Queen Elizabeth gave her charters to several companies, some of whom went westward for land to colonise in America, where the State of Virginia was founded; while others went eastward, to Asia and the Spice Islands, for commerce; and of these commercial companies the most famous and fortunate has been the East India Company, founded in 1600. In 1602 the Universal East India

Company was established in Holland, with exclusive privileges of trading east of the Cape, with a great capital subscribed by all the provinces, with full power to make peace and war, and to levy troops.

The beginning of the 17th century may be taken to be the epoch when the great rivalry among the maritime nations of Western Europe, for trade and territory, arose in earnest; and this century witnessed the greatest expansion of the chartered companies. It might almost be asserted that the commerce and the coasts of half the world, with immense tracts of what would now be called the hinterlands, were parcelled out into grants made to companies by the French, the Dutch, and the English, who were all inspired by fear and jealousy of the overgrown Spanish empire, and by a determination to break down its monopoly. The first great companies had, as we have seen, gone eastward for trade. Other companies now followed, who went westward, to America, for territory; and each company obtained from its own national Government vast tracts of land and monopolies of trade which had often been already granted to a rival. James I. chartered two companies, to whom he allotted the greater part of the eastern coast of North America. Richelieu, the celebrated Prime Minister of France, founded a number of privileged companies, allotting to one—the *Compagnie de la Nouvelle France*—the whole littoral of North America from Florida northward to the Arctic sea. These American companies were, as I have said, associations for taking possession of large tracts of land, for making what the English called plantations, the settling of colonists, and the opening out of savage countries; and in North America these settlements gradually developed out of privileged companies into self-governing English colonies. The chartered companies that continued to flourish in their original form were the great corporations, with their capital and headquarters in London, Paris, and Amsterdam, that were organised for the purpose of acquiring, not territory, but trade with countries already thickly populated as in Asia, and it was, therefore, in Asia that the keen contest between the rival commercial nations went on. During the greater part of the 17th century, this contest for the trade of the East Indies was carried on between the Dutch, English, and Portuguese; and when the Portuguese gave way the French took their place, for in 1664 Colbert had launched the celebrated French East India Company, which ran the

English very hard for nearly a hundred years in the East Indies.

We have to remember that at this period, the 17th century, the common right of all nations to trade peacefully with other countries, which is now generally admitted, at least in theory if not in practice, was then generally denied both in practice and policy. Common rights among the nations on the sea or in the sea-ports were no more recognised than common rights on the land, for trade was more valuable than territory. Each country was striving to seize and appropriate the largest possible share of any profitable commerce in Asia or America; they were all contending for masterful and exclusive possession; they were fiercely attacking every intruder on their trading ground, just as if he were an invader of their territory. There were no consuls and ambassadors in the outlying countries, and no Governments there who had both the will and the power to keep order among the foreigners. Consequently, all traders went armed, for the jealousies among them were fierce and unrestrained by any public authority. Neither Dutch, Spaniard, nor Portuguese was likely to think twice about sinking a ship or even drowning a crew whom they found poaching along shores which they had taken as their own commercial preserves, and where they claimed monopoly of trade. So the ships had to be ready for fighting at sea, while on land every trading station had to be armed and fortified. Clearly, it was only a company, supported by the State with great trading privileges, that could provide the money, exert the strength, and persist in the efforts that were necessary in those days of sheer fighting for the great markets in uncivilised and remote countries.

A single ship, or a weak party of traders, would be always liable to be taken or crushed; a small trading settlement in a sea-port was likely to be worried and plundered by some native chief or governor, while the rival European traders would certainly spare no pains to ruin its business. Out of these needs and circumstances arose the great companies, not only in England, but also in France and Holland. The Spaniards and Portuguese did not work by companies; their trade was mostly a monopoly of Government, and these Governments were bent more on territorial conquest—as in America—than on commerce, mainly because they wanted the gold and silver mines. But the Englishmen and Hollanders worked on a different system; they relied, first and fore-

most, on the wealth and energies of a large seafaring and trading population, directed by companies; and what they asked from their Government was a charter to give them authority, and good backing and support whenever they got into serious trouble with other European adventurers.

Before the middle of the 17th century, the sea power of Spain and Portugal was pretty well broken down; they kept their colonies, but they had lost their commerce. By the end of that century, the struggle for the trade between Europe and Asia, the richest in the world, was becoming a war among the companies of the three northern maritime nations—England, France, and Holland. You will easily perceive that a company, invested by the State with considerable powers of administration, of making peace and war and treaties, and acquiring possessions, was a very convenient device whereby the Government at home escaped the responsibility for the rough and ready ways of the fighting traders. It was presented with a valuable monopoly, left to its own devices, to sink or swim, as the case might be—if it succeeded, the Government demanded a share of the profits; if it got into scrapes, the company had to get out as it could. The State was a kind of sleeping partner in the concern, only waking up to lend a hand if the general political interests of the nation seemed likely to be compromised. And so the companies carried on a kind of private war among themselves, in which the Government only interfered when they could not help doing so. The extent to which this kind of private or unofficial war was carried on by companies and colonies is almost forgotten now in these days of international law, of diplomatists, and of quick intelligence sent to headquarters by wire from the uttermost parts of the earth. But if in the old days our merchants and ships' captains had been obliged to refer home for remedy of grievances or settlement of disputes with the Dutch or the French or the Spaniard in Asia or America, they would very soon have lost all their trade and all their footing on the coasts. They did no such thing in the 17th or 18th century; they took to their own weapons, and their fighting was often on a considerable scale. In 1622, for instance, when Portugal and England were at peace in Europe, there was bitter war in the Indian Ocean between the Portuguese and the English East India Company. The quarrel just then was over the trade in the Persian Gulf, and the English

company fitted out a small fleet in their Indian ports, obtained the aid of the Persians, attacked the Portuguese on the island of Hormuz, fought a naval action with the Portuguese fleet, took the fortress, razed it to the ground, and deported the whole garrison. You might have supposed that when the news got home the English Government would have been seriously scandalised, but all that stands on record is that James I. and his Lord High Admiral, the Duke of Buckingham, exacted large sums from the company as a royal perquisite or share of the plunder that the company was believed (wrongly) to have got out of the business. Of the vehement complaints of the Portuguese Government they took no notice at all. Then about the same time the Indian records contain news of a "bloody encounter between eleven of our best ships and seventeen of the Dutch," while on the other hand we know that at the island of Amboyna the Dutch cruelly murdered several of the India Company's merchants.

I hope you are beginning to see that the notion of commerce being a peaceful profession is a curious modern fallacy, quite opposed to all historical fact. When the traders had to take care of themselves, they fought on their own score and venture, as armed companies, with troops and fleets. Afterwards, when the Governments stepped in to help their respective companies, the wars became national. Throughout the 18th century almost every war in which England engaged was about commerce or colonies, and at the present moment every dispute and misunderstanding between us and other nations is either commercial or colonial. But 200 years ago commerce was a kind of private war; a rough and dangerous business, requiring not only the exchange of hard money, but also of hard blows.*

I am laying some stress upon the war of companies in the East, because of the vast importance of the results of all this struggle. In the first place, the seaborne trade between Europe and Asia has from the earliest times been the most profitable of all trades; it has made the fortune of every city or nation that has successively engaged in it; it was far more important in the 17th century than now,

when the trade with America and the Colonies has become so great. Secondly, it was a seaborne trade, carried on along the wide ocean waterways that were open to all people, so that there was nothing to prevent rivals jostling each other, quarrelling, and crushing each other if they could. You can see at once that out of this state of things came the beginning and the growth of our English navy; for a seaborne commerce cannot flourish without a navy to protect it; just as a great navy must rely for its support and recruitment on the hardy maritime population that is bred by the merchant shipping trade. The warships guard the trade, and the trading vessels feed the warships—for trade is the nursery of mariners. Three hundred years ago, in the days of Queen Elizabeth, Lord Chancellor Bacon wrote that "the vantage of strength at sea is one of the principal dowries of this kingdom of Great Britain, because," he says, among other reasons, "the wealth of both the Indies (East and West) seems in great part but an accessory to the command of the sea." What he in part foresaw, did actually happen two centuries later—the sea vantage gave England immense territories and commercial wealth both in Asia and America.

I have said that towards the end of the 17th century, the Spanish and Portuguese, who had made the first start, both in the East and West Indies, had been distanced by the English and Dutch. The struggle east and west now lay between the companies of the three northern nations—England, France, and Holland. The great French monarch, Louis XIV., had launched two powerful companies in 1664, for both East and West Indies. All along the coasts and the islands of the East Indies, on the shores of India, in Java, and the islands, the two East India Companies of Holland and England were contending for trade and trading settlements. The Cape of Good Hope had been taken by the Dutch East India Company in 1651. In North America the best part of the Atlantic sea-board had been occupied by England; and in 1670, Charles II. gave to Prince Rupert and the Hudson Bay Company a charter declaring them sole proprietors of all that vast region which stretches across the extreme north of America from Lake Superior to the Rocky Mountains, with the sole right of trade in the furs and other produce of a territory as large as Europe. It may be necessary to explain that in those days the term "Indies" bore an exceedingly wide geographical significance in both hemispheres. Under the

* "He that shall call to mind what strange effects sudden and resolute enterprises have brought to pass in India and this part of the world, will never conclude that either the Portugal or the Fleming hath attained their footing in these parts with manners or shilly-shallie, as the world doth truly take notice." 1620. Thomas Batten, Land Captain.

general denomination of the East Indies were included all the coasts of Southern Asia, from the Persian Gulf to China, Malacca, Borneo, Java, and all the rich spice islands of the China Sea. By the West Indies were meant not only the islands now known under the name, but the whole eastern coast of North and Central America, and even the interior as far as it had been explored. No ship could double the Cape of Good Hope without coming within the trading sphere of the East India Companies; while to cross the Atlantic was to trespass on some West Indian monopoly. It is not too much to say that the great companies of the 17th century were the champions and delegated agents of their respective nations in the competition for commerce and territory throughout the whole non-Christian world.

I have now reached this point. If we look round upon what was going on in the world outside Europe during the 17th century, 1600-1700, we see the maritime European nations crossing the great oceans, eastward and westward, and closing up into determined contest for trade and dominion, in Asia and in America. In South Asia the chartered companies led the van; in North America the colonising emigration. You will remember that all the companies were by this time set upon acquiring not only trade but territory. The French companies were formed to acquire lands; the English company in India began about this time to follow the same plan; and the Dutch had always founded their commerce upon the principle of seizing the best positions. The Dutch were, in fact, all through the 17th century our most formidable rivals by sea. But the long wars on the continent of Europe were rapidly enfeebling Holland at home, and we had been fighting the Dutch by sea, with the consequence that just as the Spanish naval power had been broken at the end of the 16th century, so the Dutch naval forces were cut down and greatly reduced at the end of the 17th century. And thus at the end of the 17th century, France and England stood alone in the forefront of the adventurous and trading nations, having distanced all other competitors.

The transmarine possessions of France were at this epoch larger and more important than those of England, and Spain held a vast dominion in America. One of the chief motives that caused England to declare war against Louis XIV. in 1701 was the fear lest, if a French king succeeded to the Spanish throne, the combined power of France and

Spain would crush English commerce and colonies. But the great war between 1701 and 1713, checked the growth of colonial France. It began to thrive again, however, during the following thirty years of peace. By the middle of that century, say 150 years ago, not only the commercial, but the colonial rivalry of these two powerful maritime States, France and England, had reached its climax in Asia and America. In Asia the fight was between companies, in America between colonies.

I will follow out the fortunes of the French and English companies in Asia, before turning to colonial questions. In 1744, when England and France went to war, the French and English companies began fighting on the Indian coast; but it ended in 1749, leaving both parties as they were, except that the war had given to both of them a taste for warlike operations, and had inspired the French with ambitious ideas of setting up a dominion in India. At that time the English wanted to stick to their trade, and it was entirely the governor of the French company, Dupleix, who first took up plans for acquiring possessions on the Indian mainland. With these ideas of war and dominion in their heads, the two companies very soon came again to blows; for each of them now kept up a small army, and the neighbouring Indian princes were constantly asking these armies to help them in their own wars. These princes had discovered the weight of European metal on a battlefield, and were quite ready to pay handsomely for a temporary loan of the companies' troops. The result was that both companies got mixed up in the quarrels of the native chiefs, and carried on a brisk non-official war for about two years, while England and France were at peace in Europe. While their troops exchanged volleys in the field, the two companies exchanged bitter reproaches and fired off angry letters at each other from their respective headquarters, accusing each other of scandalous behaviour, and each writing home to implore its respective Government to interfere against the other's utter disregard of the most ordinary morality. This went on till the quarrel grew so hot, and so much money was spent in fighting instead of trading, that the Governments at home were obliged to interfere, and to patch up a reconciliation, and so, after two or three years' scuffling and skirmishing in Southern India, a peace was made between the French and English companies.

After this there was a kind of truce in India

for about four years, during which time the French and English companies were facing each other sulkily and suspiciously. Then in 1756, broke out the famous Seven Years' War in Europe, which was caused, so far as France and England were concerned, by the quarrels between the French and English colonists in North America, and this kindled again the smouldering hostility between French and English companies in South India. The result of that war was that the French lost all their colonies in America and all their possessions in India, excepting two or three small towns on the Indian sea coast, which they still hold. This you will understand was a national war, not a company war; and it ruined the French East India Company. One reason of its downfall was that in France the East India Company was a much weaker institution than in England; it was badly managed, it got into heavy debt, and it relied far too much on the financial assistance of the Government; it was propped up by State loans and various privileges and monopolies; it subsisted on grants in aid from the Treasury, and in consequence the Government officials were always interfering in the management. The French company was heavily in debt to the Government, while in England the Government was in debt to the company. The French company was poor and had to borrow money from the French Treasury; the English company was rich and lent money to the English Treasury. For with us the East India Company's business was managed independently by great merchants with a long experience of Asiatic affairs, with a strong parliamentary connection, and a large reserve of capital. And all this superior wealth and energy were brought into full play by the vigour of our free parliamentary system, which understood and actively pushed forward the real interests of the country, whereas the French were under a despotic and inferior set of ministers, with a bad king (Louis XV.), who was under the influence of his mistresses. It was the ministers and the mistresses that ruined French administration. These were the immediate causes that reduced the French East India Company to total insolvency. But at bottom of all lay the real reason why the French were driven out of India, and this is that the English were strongest at sea.

It must be quite obvious to all who carefully survey the situation that when two great nations carry on a war in a distant country, which can be only reached by a long sea

voyage, that nation which has the superior navy can break the communications of its enemy, can cut off his supplies and reinforcements, and can starve him out. Now, in the Seven Years' War the English were far stronger in warships than the French; they swept the Frenchmen out of all the seas, and blockaded the whole Indian coast, so that the forts and the garrisons gradually became weaker, and surrendered one by one. By 1763, the French dominion in India was completely suppressed, and, by 1770, their company went bankrupt. This left the East India Company master of the situation, and laid the foundation of the British Empire in India. The remaining history of the company is neither more nor less than the history of the rise of the British Empire in India. And when, in 1858, India passed from the company to the Crown, the greatest of all the old privileged companies became finally extinct.

Having traced out rapidly the marvellous expansion of a chartered company in Asia, I must now refer briefly to the very different course taken by the development of the old chartered companies in North America, where they became transformed into self-governing Crown colonies. You will recollect that the English first occupied North America by the agency of proprietary bodies, whose charters were substantially the same as those granted to commercial associations. At the end of the 18th century, the East India Company was ruling Bengal by the authority of a Royal Charter precisely similar to that under which a governor and company had taken possession, a century or more earlier, of Massachusetts.*

What caused associations so similar in origin to follow such divergent lines of development was that their circumstances and objects were different. The business of the American adventurers was not commerce, but the settlement and cultivation of land. Excepting only the great Hudson Bay Company, they were mainly agents for emigration. You will easily understand that whereas a trading company naturally seeks to deal with populous and productive countries, which have much to

* "The united proprietary representative sovereignty of the lands of Bengal is virtually in right, possession, fact, and relative circumstances, but on a large imperial scale, almost precisely what private territorial property was in some provinces of North America, with respect to local or more extensive national interests of the high ruling protective State of Great Britain, and differing only in the descriptive terms of conquered and colonised dependencies."—*Grant's Analysis*.

sell and more to buy, like India and China, what a colonising company wants is just the reverse, for the colonist is looking for some unoccupied or scantily-peopled country, where there is plenty of fresh land available. He goes to settle and cultivate, not to barter goods and bring back his profit. A true colony in the English, and indeed the Latin, sense of the word, is agricultural, and I do not think this sort of colony existed before the discovery of America.

When Europe discovered America, she found a vast continent very sparsely inhabited, especially in the north, where the immense tracts were only peopled by hunting tribes. Into these vacant spaces the stream of adventurers from the European shores of the Atlantic soon began to flow; first trickling slowly, then faster, until in our own century the emigration has become more like a torrent. The Spaniards and Portuguese seized the centre and the south of the continent; the Dutch, English, and French, occupied the north. Of course, the hardier and bolder spirits led the way, and did all the rough work of clearing the ground and fighting the native Indians. The French in Canada and the north did very well at first, but their colonies were kept far too strictly under official regulation. The French Government insisted on keeping a tight hold on them, and the colonists were much troubled by the activity of the Roman Catholic Church, which sent out large establishments of priests, whose business it was to see that the colonists were orthodox, and to convert the native Indians. On the other hand, the English colonies were formed on just the contrary principle; they were mainly founded by men who had left their native land to escape from kings and bishops, who fled from persecutions by Church and State, and who would undergo any risks and hardships for the sake of civil and religious liberty. While the French and Spanish imported into their colonies their official system and their Roman Church, the Puritan English, who were the backbone of the emigration, insisted on leaving at home their religious establishment, positively declining to import it either for their own use or for that of the natives. This radical difference of origin runs up through the whole history of French and English colonisation in America.

The Southern half of the American continent was conquered by the Spanish and Portuguese, who are the ruling races to this day. In North America, where, as I have said, the old companies had merged into Crown colonies,

the colonial quarrel became a trial of strength between French and English, and during the 18th century it was fought out, and the prize was won by the English, who expelled the French and took all their possessions except New Orleans. I may add that our success in North America, as in Asia, was mainly due to three great advantages:—first, we had a better Government; second, free institutions; third, a much more powerful navy.

But there were other reasons why our colonies won. In the first place, the founders of the chief English colonies in North America were mostly refugees. I mean men who had sacrificed everything at home to their principles, and who had fled across the ocean to escape what they thought tyranny, whether of church or state. Such men were sure to have great force of character and stubborn hardihood. Secondly, the English colonists soon became far more numerous than the French, they settled on the land and multiplied much faster, they numbered 1,000,000 in the middle of the last century when the French were only 50,000. Thirdly, the English intermarried or intermixed with the Indians much less than the French, and all experience in colonies shows that the purer race is the stronger race. Well, the two nations soon began to quarrel in America over land, just as they were quarrelling at the same period in India over trade. The English were settled in the country that borders the Atlantic; the French were in Canada, to the north, and they tried to occupy the great inland tracts behind the English—what the Germans call the hinterland—which would have cut us off from all trade with the interior. The colonists, like the Indian companies, began to fight with each other unofficially; I mean that the French and English Governments backed each its own countrymen without declaring war publicly, until at last matters got to such a pass that the two nations fell openly to blows, and during the Seven Years' War the French lost America just as they lost India. Here, again, sea power told heavily in our favour; the success of the English was greatly due to their superior navy; they cut off the French communications across the Atlantic. And so you see that colonies and commerce beyond sea depend for their connection with the mother country on naval superiority. On the other hand, a country without colonies or commerce cannot support a large navy, which requires friendly harbours and stations all over the world.

I hope I have now explained to some extent how companies laid the foundation of the

British Empire beyond the sea in the 17th century, and how in the middle of the 18th century they acquired for us a great dominion in both Asia and America. They were allowed to go forth on their adventures to establish themselves and to broaden out their possessions, to compete for trade in Asia, or to cultivate remote lands in America. This brought them into contact with other foreign nations, whose subjects were doing the same. But the contact meant collision; as soon as two nations came across each other's path one had to give way. Then came, as I have said, first, unofficial fighting—war between companies and war between colonies; and secondly, public fighting—war between the nations.

We all know what came in North America last of all, a war between the English Government and its own colonies. So long as the French in North America were threatening the English colonists they were fairly tractable, because they needed the protection of the mother country. But when England had driven out France, our own colonists became very hard for England to manage, and after a war they declared their own independence. And so by the end of the last century we lost all our North American colonies, for I don't call Canada a colony in the strict sense, it was not originally founded by English colonisation, it was conquered by England from France, just as the Cape was originally conquered from Holland. Precisely the same thing happened at the beginning of this century in South America; the Spanish and Portuguese colonies all rebelled against the Home Government, so did Mexico, and now the whole of South America and Mexico are independent. At the present moment we are spectators of the desperate struggle of Spain to maintain the two islands which are the last relics of her magnificent empire in the New World.

After the loss of our American colonies, the main currents of English enterprise abroad seem to have run into fresh channels. We had lost a great dominion in North America by 1783, but in 1787 we made good our first foothold in Australia, which has since grown into a magnificent colony, while by the beginning of this century we had taken possession of the Cape. In these countries, in Australasia, New Zealand, and to some extent in South Africa, we have had the great advantage of having no other European rivals to contend against as we had to contend against France

in India and North America. And since the only road to these countries is by a long sea-voyage, our command of the sea enabled our colonisation to grow and spread undisturbed. These countries, moreover, have immense value to us as colonies, because of their excellent climate, in which Europeans can work with their hands and bring up their families. Commerce is independent of climate, the trader goes everywhere, into the hottest, the coldest, the most unhealthy, regions. But the colonist can only thrive and make a home in the temperate zones; within the tropics he cannot exist. It has been said by the French, and truly, that every colony is really held by the women, for unless the women emigrate with the men, and until the families settle down, the occupation has no root. And I may add that this is the more essential, because if the colonist does not bring his womankind, if he intermarries with some inferior native race, he is sure to lose vigour and fall behind in civilisation.

But if we survey the present state of the world, we shall see that the regions with a temperate climate, where the white man can live, work, and rear a family, are rapidly filling up; there are very few vacant spaces of that kind now remaining where the climate is good and the land profitable. Yet the emigration of the northern European nations—of English and German—is going on as fast as ever, stimulated by two causes: too many people at home, and one might almost say for England, too much money. When the energetic portion of a people cannot find scope for their energies or satisfaction for their wants at home, they go abroad for it; and when capital cannot get a fair return for home investments, the money goes abroad also. That is the state of things in England, where wealth flows into the city and accumulates, until there is an overflow all over the world. On the Continent matters are different; there is not such a pressure of population and of wealth as in this little island of ours. But we have seen in our day a great revival of colonial enterprise, both in France and Germany. The Governments of those countries have noticed with natural jealousy the immense spread of the English colonial possessions. They have discovered that it is politically dangerous to keep their people pent up at home; it creates discontent and a sharper struggle among the classes—among those who have and those who have not; it is apt to cause impoverishment of the national character; and so France and Germany have

been taking up eagerly again the question of colonies, of adding to the national estate by seizing great tracts of land in other parts of the world. They want to be even with England, who has been doing the same thing steadily all through the latter half of this 19th century, and, above all things, they do not want the English to go on taking up the trade with all the outlying half-barbarous countries of the world, in Asia and particularly in Africa.

But I have already said that there are hardly any tracts left in the world which are suited for cultivation by Europeans—tracts like Australia and Canada, where white men can settle down and labour with their hands. There are, however, wide regions where a valuable trade can be developed, by capital and good government, with the barbarous inhabitants; there are also tracts which will yield great profits to mining industry. For the security of trade and for the safe investment of the necessary capital, it is obviously convenient to take possession of these regions, to place them under protection, and to bar out in this way rival nations. Each State, therefore, makes haste to mark out its own protectorate, to assert dominion over it, and thus to throw open a great tract of country for development by the enterprise of the State's subjects. Now the point to which I would draw your attention is that, while the old chartered companies for trade have become extinct, this partition of Africa among European nations, which only began about twenty years ago, has led, in England and Germany, to a revival of the great companies under a territorial charter. The system is, however, a kind of new variety. Its main object is not precisely colonisation, as with the old North American colonies, for the emigrants rarely go out to settle in the new tracts, to plant families and till the land. Neither is commerce its main business, for the new company has no trading monopoly like the old commercial companies; and in some of these immense regions the trade has to be created. Nevertheless, as I began by saying, the charters granted to these English companies within the last fifteen years or less, substantially resemble in regard to powers to acquire possessions, and jurisdiction to govern them, the charters issued by the Crown in the 17th century.

Now you can easily understand that enormous tracts, most of them very well peopled by uncivilised folk, cannot be taken up and worked without some trouble and some opposition, even in Africa. You cannot cast a net over

millions of men without finding them a little restive and very suspicious. They often show an ignorant impatience of being governed by foreigners, according to foreign ideas, and a deplorable blindness to the benefits of civilisation. They quarrel with us, and they quarrel among themselves, and it is not always easy to keep good order. But the most serious difficulty of the modern European company arises out of the jealousy of its European neighbours and rivals, or out of the clashing and contrary interests of other European races in or near the same country. In the old days such disputes were usually settled, as I have explained, by a kind of private war between the companies or the colonists; and their Governments were not called in until matters had gone so far that the quarrel became national. In these latter days of telegraphs and rapid communication all over the world, any slight collision in some far-off colony, any encroachment upon a foreign sphere of influence, any skirmish on a wild border, or difficulty with the native chiefs, is at once reported home, and the European Governments begin to demand explanations or to threaten reprisals. The consequence is that a company needs more looking after than in old times, for a mistake may, and will, make its Government responsible. The competition for trade is as keen as ever, the contest for dominion is keener than ever, the different nations and governments are very much more ready than formerly to take up quarrels over territorial boundaries, and to make them questions of national honour. We have to remember that other European nations—the Germans, the French, and the Belgians—have annexed in Africa almost as much territory as the English, and that the Italians, up to last year, had also claimed the protectorate over an immense tract in East Africa. But the difficulties that surround the modern system of companies are already showing themselves. The German companies, which were founded some fifteen years ago in imitation of our own, are, I believe, either dissolved or dissolving; they have made over their possessions to their Imperial Government. If we set aside the North Borneo Company, which is on a comparatively minor scale, the only great territorial companies now surviving in the world are the English companies in Africa.

And I doubt whether these companies, as proprietary governors of territory, are likely to last long. The British East Africa Company, which pierced the centre of Africa to Uganda from the east coast, soon got entangled in the

disputes of the native tribes, and, in complications with French interests, they have resigned their charter, and the English Government reigns in their stead. The Niger Company on the west coast have had several native wars, and their relations with the French are just now giving us some anxiety; we already hear something of a desire on their part to cede their governing and diplomatic responsibilities to the State. The Chartered South Africa Company stand alone, to my mind, as the last surviving example of a great association, vested by charter with rights of property and administration over a vast domain. Two years and more ago, they came into serious collision with the Transvaal Republic; they have had wars with the natives, and manifold financial vicissitudes. Nevertheless, their territory goes on expanding under the vigorous direction of Mr. Rhodes, and Rhodesia now means a tract of 800,000 square miles on both sides of the Zambesi river; its landmarks have been pushed northward to the Tanganyika Lake. But we have been very recently told that a significant change in the constitution of the country is to be expected. It is proposed to convert Rhodesia into a self-governing colony, on the model of other South African colonies, which shall be partly under the control of the Company, as the Company is under the control of the Crown; the Company retaining its rights to dispose gradually of the land and the minerals by allotment to those who apply for concessions. If this is done, if the land as well as the local administration passes to settlers in the country, the constitutional change will have followed, very remarkably, the course by which, in the 17th century, the old proprietary companies of North America, the Virginian Company for instance, were transformed into self-governing colonies.

The truth seems to me to be, that in this latter end of the 19th century the system of chartered companies has been revived too late. It answered well enough in times when rival traders or colonists could settle their disputes by diligent fighting among themselves, without prejudice to international relations. But companies cannot now contend with the representatives of foreign States; and in many parts of the world the native rulers or races have now got modern arms, and know how to use them. War has become a much more serious business everywhere; the national governments are made directly and instantly responsible for the acts of the companies, and the state officials

often have to watch what is done so closely that they might as well do the work themselves, though I admit that in that case much of the work would not be done at all.

The present situation may, therefore, be summed up in this way. In North America, the old proprietary companies have long ago merged into the federation of independent States. In Asia, where India was once vested in a great corporation, we have now the Indian Empire. The companies have finally disappeared from both continents where once they possessed vast territories. It is no longer possible in Asia to entrust them with charters empowering them to treat independently with Asiatic rulers, to occupy settlements, to raise fleets and armies, or even to administer their own concerns by their own ordinances. You have only to look at what is going on at the present moment in China to see that the interests of national commerce in those regions, the taking up of vantage points on the coast, and the work of holding our own against European rivals have now necessarily become important affairs of State, and matters of keen international controversy. Two hundred years ago the business of gaining a footing in China, of occupying settlements, treating with the Mandarins, and fighting with foreign rivals, would have been left to some powerful companies; and diplomacy would have only come in when the quarrels grew serious. Africa alone remains, and in Africa the only European nation which still ventures to operate through companies is England. I have already given some reasons for my belief that even in Africa we shall soon see the last of the chartered companies in spite of their recent revival. I think that they have done their work, and a noble work it has been, for the nation; that in the present state of the world they are no longer convenient agencies for the acquisition and administration of territory. And certainly it seems to be best that they shall not undertake to do any more fighting for us; as that is a business which in these days of international sensitiveness a State had better do for itself. In short, we are discovering by experience that the system is not suited to modern circumstances; it is too loose and irregular; it mixes up dividends with administration; it cannot keep public duties and private interests sufficiently apart. It is not a satisfactory governing agency in lands where there is a large native population which must be cared for and protected; for where there are living together on the same territory diverse races of

which one is far stronger than all the others, I doubt whether the weaker folk can be sure of fair play under any administration that is not an imperial, and, therefore, an impartial arbitrator among local interests and prejudices.

Accordingly, my conclusion is that the long and famous record of English companies is very near its close. I have endeavoured, very briefly and imperfectly, to take a rapid survey of their past history. You will have seen, I hope, that the system has played a very great part in founding, extending, and consolidating the vast dominion of Great Britain beyond seas; they have spread our commerce, our language, our manners, and, I hope, our civilisation; they began the colonisation of North America; they conquered India; they have opened out and pacified a great dominion in Africa. They have also been closely connected with the growth of our sea power; they have always been, and are now more than ever, supported and secured by our sea power, because all the possessions of the maritime nations of Europe in Asia and Africa depend entirely on the control of the water-ways. It was through the support of our navy that our trading company secured India in the last century; it is on our command of the sea routes that our English company now relies for the safety of the vast domain which it is marking out for the mother country in South Africa. In the matter of capable administration and intelligent dealing with subject races their record shows mistakes and shortcomings; yet we have to remember that the whole history of the management of dependencies is full of errors and failures; it has been largely a story of mismanagement, and I really believe that in governing distant lands the companies have, on the whole, been quite as successful as the India Office or the Colonial Office. And so we may still look back with some pride and satisfaction upon their adventures and their achievements beyond sea; and we may all resolve to do our best to act justly toward the immense populations that have come under our dominion, to live peaceably, so far as may be, with our rivals and neighbours in Asia and Africa, and to make our dominion in those continents a source of moral and material benefit to the whole British Empire.

DISCUSSION.

The CHAIRMAN said, however much they might have known of the broad facts contained in Sir Alfred Lyall's sketch of chartered companies, one thing was certain, they were never so lucidly arranged

in their minds before, and it must be admitted that for its clear presentation of actions and motives, and especially for the inspiring suggestiveness of the contents of his paper, they all owed him a deep debt of gratitude. He had marshalled the facts which he had collected for the purpose of instruction rather than amusement, and they must be dull, indeed, if they did not profit by the stirring thoughts he had aroused. Carlyle said that history was philosophy teaching by experience, and he seized on that saying with the view of pointing out what lessons might be learnt by reflecting on what they had learnt of the lessons of the 17th and 18th century. When he was reminded of the lessons of the 17th century, he was led to compare them with those now prevailing, and it was impossible not to see that there were some striking resemblances between those of the present period and those of the old-fashioned days of which Sir Alfred Lyall had spoken. When the collapse of the East India Company, through bad management, heavy debt, and the interference of Government in its affairs, was mentioned, his mind reverted to what they had lately heard about the South African Company: its collision in the Transvaal and with the Matabele, the Government Commissioners just appointed to supervise its future operations, its £10,000,000 of debt, its limited revenue, and the credit of the Government which was sought for the railway to Tanganyika. When Sir Alfred Lyall alluded to the adventurers in America, and then to the struggle for territory between the French and English; when the French tried to occupy the hinterland of the Atlantic coast, to prevent the English getting the trade of the interior, it appeared to him as if there were some strong resemblance to what had occurred to-day in Western Africa. There also the British were in possession of considerable coast land, and the French had come down from the north and occupied, as they did in America, the hinterland of the Atlantic coast to cut them off from the interior. As in America, both nations backed their colonists, and finally fought together for seven years, until the French were expelled, must it be inferred that when the British and French colonial forces were tired of staring at each other, the armies of both countries would join in conflict until one or other retired? Who could tell. They might be sure, however, that they would not be fighting because of the value of the African hinterland, but because of the unfriendliness of the Power which went out of its way to confine us to the coast. A friendly Power would not do that to its neighbours which it would not like to have done to itself. If they were compelled to fight, it would be because all other means had failed to prevent a recurrence of those unfriendly and irritating actions. When Sir Alfred referred to the bold crusades of the 17th century in seizing and appropriating trade grounds in Asia and America, and the contention for extensive possessions, he was led to think of the events of a few weeks ago at Kiao-chau and Port Arthur; and the

passionate denunciations of the Press for the passive resistance it was thought our Government had opposed to those acts. He fancied, from the tone of the Press, that the spirit of contention was as much alive in this country as ever. There also came to his mind the sudden expansion of the Luderitz concession fourteen years ago to the huge domain of Germany in South Africa, and how the petty district conceded to her on the east coast expanded into a large tract extending as far as Tanganyika, and that a decided incursion and occupation had been made in British West Africa into a sphere of influence, and on the Upper Nile near Lake Rudolph. All this made him think that, despite the advance civilisation had made within two centuries, the contention for trade and trade ground was as vigorous as ever, and that the age was as ready for the excitements of the 17th century as were the Spaniards, Portuguese, and Flemings of that period. He could not help wondering, during Sir Alfred's sketch of the decline and fall of the Spanish Empire, through the jealousy of the French, Dutch, and English, whether any present had the faintest suspicion that the fate of the British Empire might be some day somewhat similar. We were too near to the late events to take in dispassionately their full meaning, and to venture to prophesy, but it appeared to him as if in the mirror of the past held out by the reader of the paper, they might trace a dim likeness of the future, especially when Sir Alfred admitted that we had also in our turn become the object of jealousy to Germany, France, and Russia, and, might they not add, to the United States and Japan? Sir Alfred clearly showed that only a combination supported by a warlike and ever-ready State could persist in the work of securing trade during those old fighting days, but now that our attention had been excited, and they foresaw the possible contingency, might they not ask themselves what would happen to a State that would be reluctant to fight for either its rights, trade, territory, or prestige. Was it possible that a State could long survive a reputation for tranquilly suffering unfriendly acts, of remaining unmoved by any number of provocations, and quietly disregarding invasions of its territory. The old writer Batten said that the commerce of the East was not built up with manners and shilly-shally, and he was sure the most courteous manner and the most Christian forbearance would never retain it. It was certain, however, that diplomatic graciousities called by Batten "shilly-shally" had contributed a great deal to the preservation of peace and trade since the Crimean war, but, unfortunately, the times were changed, and the competition for trade and colonies was becoming keener every year. The desire for colonies, in fact, had become ferocious—a veritable land hunger—because some Powers had already tasted the sweets of their recent annexations, and as it increased, the same unscrupulousness as characterised the 17th century would be manifested again. If we had only Christian protests and

manners to repel poachers on our territory, we should be in great danger of being squeezed like an orange. Sir Alfred Lyall had laid stress on the fact that the nation which had the superior navy could break the communications of the enemy, cut off his supplies and reinforcements, and starve him out. That was very true provided that that nation had the courage to use its navy. The strongest navy on the seas was no help to a nation if the ammunition employed was only manners. If Germany possessed such a navy as England to-day did they think she would stand the incursions we had so patiently endured? He felt very certain that if France owned such a navy she would never have borne insolence and provocation for 14 years as we had done since 1884. There was one little remark in the paper which made him feel melancholy for a short time. One could not help becoming attached to a thing that had served one well, and to hear that chartered companies, which had so extensively added to our empire in Asia, America, the West Indies, Borneo, and Africa, were now out of fashion, and that the last of them was to disappear shortly rather saddened him. But on reflection he had been encouraged by reminding himself that civilisation was not yet at the end of its resources. A frivolous excuse was all that was needed now-a-days when they were fevered with a craving for territory. The killing of two missionaries was all that Germany wanted for taking Kiao-chau. The want of an ice-free port was sufficient for Russia to annex Manchuria and the Liaotung peninsula. The necessity for studying the flora and fauna of Kilimanjaro caused the Emperor William to demand that snowy mountain, and the wish not to be behind Russia caused France to desire a big slice from Southern China, and then the need for a northern coaling station inspired England to take Wei-hai-Wei, and thus although chartered companies were not to be used in future as intermediaries for Governments the resources of modern civilisation were not exhausted. He merely wished to point out how very suggestive he found this very able, interesting, and historical sketch, and thought few would refuse to agree with him in his conclusions respecting the great advantage which chartered companies had been in the past to the nation, and that for the future they would be considered as somewhat out of date.

LORD BRASSEY, K.C.B., F.R.S., said, having held the position of deputy-chairman of two of the companies to which reference had been made, the North Borneo Company and the East Africa Company, he desired to say, speaking with a conviction founded on practical experience, that he subscribed unreservedly to the views expressed by Sir Alfred Lyall in the closing pages of his extremely interesting paper. He was thoroughly convinced that it was inexpedient for a Government to grant charters to a company which it was not prepared either to resist or control. He would only add that he could not subscribe unreservedly to some of the observations which had fallen

from the Chairman. The view which that gentleman appeared inclined to maintain seemed to him to be an aggressive one, and while he was as fervent as any man in the desire that we should be well armed and prepared to vindicate our just rights, he did not know that we had any cause to complain of our failure to expand our empire almost as rapidly as was justified by our available means of government.

Sir RICHARD TEMPLE, Bart., G.C.S.I., C.I.E., F.R.S., said, as it was getting late, it appeared to him that he should best serve the interests of the meeting by proposing a vote of thanks to the reader of the paper. With regard to Sir Alfred Lyall, he must express the pride and pleasure he felt in listening to so excellent an address from one of his brother officers of more than thirty years' standing; with whom he had been brought up officially, and with whom he had served on many arduous occasions. Sir Alfred was now illustrating the latter part of a most distinguished career by lectures, such as these, of a philosophical, historical, and statesmanlike character for the edification of his countrymen, and for stimulating that patriotism which surely was as much needed as ever it was in the days of the Georges, or even Queen Elizabeth. They were also privileged in having as Chairman one who was beyond all comparison the most successful of modern travellers—a man who had been the means of spreading light over the darkest part of the world; who had done great things for many nations, but most of all for that British race which was proud to own him amongst its most distinguished sons. He thought with Lord Brassey that some of the Chairman's remarks were open to comment, though he agreed with him in the main, and thought what he said would be very useful at the present moment, when he remembered that just now in the far East there was springing up as much competition as ever existed in the Spanish Main, North America, or the West Indies, when the Spanish-American war threatened England with about the most completely world-wide complications to which they had ever been subject, and for the treatment of which the public could not too soon prepare itself. In a few months there would be grave questions arising as to the ownership of the Philippine Islands, and a possible alliance between England and the United States, which undoubtedly meant the whole question of the Monroe doctrine in South America. Therefore, it was time they should gird themselves up morally as well as materially. He quite agreed with the Chairman that they might say if either France or Germany possessed the preponderating sea power, which was the power of the 19th century, neither would have behaved quite so mildly as we had; but were we to blame for that, or were we less successful? The question was did a strong aggressive policy always do good to the nation which employed it. He thought we had been most considerate and had never used our giant strength at sea like a giant. In the

partition of Africa who got the lion's share of the whole? He should say England, for she came out with a territory of several million square miles and a population of 50,000,000, which was more than equal to the share of any other nation. Even in the last affair, suppose we had been a little inclined to concede to Russia, would it turn out that we had the worst of the competition? China was not to be partitioned quite in the same sense as Africa, but it would be vain to disguise the fact that the partition of the commercial sphere was already beginning in China, and that commercial sphere would become ultimately the Imperial sphere. In that who had the lion's share? Undoubtedly England, in spite of all that might be suggested as to the shortcomings of the Government. He did not believe they would turn out to be such shortcomings after all. These were facts which could be proved statistically, and if so, they need not distress themselves by any supposed meekness and undue disposition to concede. Conciliatory plans practically proved most successful in the end. Undoubtedly we did show that we could act forcibly if required, as in the matter of Wei-hai-wei. Did it show weakness that on the same morning that our intention to take it was announced, ten British ironclads rendezvoused close to the mouth of the harbour. That showed that the spirit of our Government was still equal to that of the Pitts. As to the spirit of the nations, other countries might do well to observe, if they wished to preserve the peace that although the present Government was generally supposed to belong to that part which looked after foreign matters, nevertheless it had fallen behind the aspirations of the people, and was being complained of for not having done enough. He thought it would be proved to have done enough, but still the fact of it being complained of, even without due ground, proved that the instinctive patriotism of the British race flamed as brightly as ever.

Sir OWEN TUDOR BURNE G.C.I.E., K.C.S.I., seconded the vote of thanks, and as chairman of the Council, wished to express the appreciation of the Society at large, both to the reader of the paper and to the Chairman. They were always glad to welcome distinguished men in those rooms, and were particularly fortunate in having this meeting addressed by one of the leading men of our Indian service, and presided over by a man whom they all respected as a great traveller, and who, they were all glad to find, was not losing his fighting qualities, although he had sought that repose which he deserved in the peaceful atmosphere of the House of Commons.

The motion was put by Sir RICHARD TEMPLE, and carried unanimously.

Sir ALFRED LYALL having thanked the audience for their appreciation of the paper, said he would

only add that he felt much honoured and touched by the words in which Sir Richard Temple alluded to old times and old associations when he served under him in India. All who were there would remember the vigour of character, strength of action, and firmness of purpose which carried Sir Richard Temple through many difficulties, and led him to distinctions which had rarely been equalled in the Indian services.

Miscellaneous.

THE PHILIPPINE ISLANDS.

Local and European authorities estimate the area of the Philippine Islands at 150,000 square miles, and their population at 8,000,000 to 10,000,000. The island of Luzon on which the city of Manila is situated has a population of 5,000,000, and the next largest island is Mindanao. There is but one railway in the islands—from Manila to Dagupin—a distance of 123 miles. It is a single line and well built, steel rails being used through its entire length, the bridges being of stone or iron, and the station buildings substantial. The Government assisted in the construction of the road by making valuable concessions of land with right of way through its entire length, and by guaranteeing 8 per cent. per year upon the stock of the road for a period of 99 years, when it becomes State property. There are about 25,000 Europeans resident in the islands, not including the troops. Some 12,000 are established in the capital, Manila, the centre of the colonial Government. English, Spanish, and German houses are engaged in trade. The land is fertile and productive, and lacks only intelligent cultivation. Abaca (manila hemp) is one of the chief sources of wealth of the country. Sugar cane does not give such satisfactory results owing largely to the ignorance of the planters. The average production is about 176,000 tons, while that of Cuba in the time of good yields was 720,000 tons. The sugar goes almost entirely to Japan, England, and the United States. The cultivation of tobacco is one of the most important industries, although it is said to be capable of much greater development. The native coffee, although not equal to the mocha, or Bourbon variety, has a fine aroma. Cocoa trees grow in abundance, and the indigo is famous for its superior qualities. The late United States Consul at Manila says that during the quarter ended December 31, 1897, there were exported from these islands to the United States and Great Britain 216,898 bales of hemp (280 lbs. per bale) of which 138,792 bales went to the United States and 78,106 bales to Great Britain. During the year 1897 there was an increase in the export of hemp from the Philippines to continental Europe of 19,741 bales; to Australia, 2,192 bales; to China, 28 bales; to Japan, 2,628 bales, and to the United States, 133,896 bales. Of the total exports of hemp from the Philippines for the ten years ended

1897, amounting to 6,528,965 bales (914,055 tons) 41 per cent. went to the United States. During the same years the Philippine Islands exported to the United States and to Europe 1,582,904 tons of sugar, of which 875,150 tons went to the United States, 666,391 tons to Great Britain and 41,362 tons to continental Europe, showing that of the total exports more than 55 per cent. went to the United States. In 1896 the total imports into the islands were valued at £2,100,000, and the exports at £4,030,000.

SUGAR BOUNTY QUESTION IN RUSSIA.

In view of the probability of the question being raised in Parliament, of the imposition of counter-vailing duties on sugar imported into England from countries paying an export bounty on sugar, Consul-General Stewart, of Odessa, has recently reported on the agriculture of Southern Russia, and explains that, though it is generally supposed in England that Russia does pay an export bounty on sugar exported to England, she really does not do so. To replace the former sugar syndicate, which no longer exists, the Government has now an office at Kieff which has made the following rules:—Every year, of the product of the factories, 31,000,000 poods (9,964,000 cwts.) of sugar crystals are put aside for home consumption, and 833,000 cwts. as a reserve. Whenever inland prices at a station near Kieff rise during the months from September 1st to the end of August to 3½d. per pound, or from January 1st to the end of August to 3½d. per pound, then so much of the 833,000 cwts. of reserve are thrown on the market until the price of sugar comes down to the fixed price. All factories are allowed to include about 20,000 cwts. in the 9,964,000 cwts. allowed for home consumption; if the quantity does not, at 20,000 cwts. per factory, amount to 9,964,000 cwts., then the factories making more sugar than 20,000 cwts. are allowed to make up *pro rata* from their factories the 9,964,000 cwts. required. Then the reserve stock of 833,000 cwts. is made up *pro rata* from the factories producing more than 20,000 cwts. The factories producing more than 20,000 cwts. must export all produce remaining on their hands after the above quantities have been made up. If they do not export the quantities left on their hands, instead of an excise of about 3s. 8½d., which is levied on all sugar, a double excise of 3s. 8½d. additional will be levied on the quantity they should have exported, as sugar can only be exported abroad at a loss, and the single excise which has been paid on all sugar (though returned on export) does not cover the loss of the sugar factories, the owners of which often do not care to export themselves, but are ready to pay merchants an additional sum to cover the loss on exported sugar. At present the Odessa merchants who will export sugar are being paid 3s. 8½d. returned excise, and at present the sugar factories pay them about 3s. 3½d. in

addition, so as to avoid the double excise. The Russian Government do not pay a single penny of bounty on sugar exported to Europe; at one time they paid a bounty on sugar exported to Persia and Bokhara, but that is no longer paid. Comparatively a few years ago, it required about 13 tons of beetroot to produce a ton of beet sugar, but by careful cultivation and the selection of seeds from only the best sugar-producing sorts, the quantity to produce a ton of sugar has been reduced to from 8½ to 9 tons of beetroot.

Correspondence.

EVOLUTION OF THE CYCLE.

In the discussion on Mr. Starley's interesting paper (18th inst.) on the "Evolution of the Cycle," several suggestions were made as to points of design, and details of construction which, if amended, might contribute to the efficiency of the machine, the convenience of riders, and the profitable development of the trade.

I would like to add that the tubular frames now generally used are objects of suspicion to custom-house officers as possible receptacles of excisable articles of small bulk, and that their right of search and internal examination, for which no facilities have hitherto been provided, would, if thoroughly exercised, at least involve damage to the machine.

It should concern makers to obviate any difficulties of this nature which would be very vexatious, a hindrance to travellers abroad, and a check to our export trade. Already such cases are reported to have arisen, and as regards bicycles for military equipment, it is notorious that the tubular frame has been used for the concealment of despatches.

Whatever may be the merits of curved frames—and they have been especially used for ladies' machines—it is obvious that accidental distortion of a frame having only straight members is the more readily detected and corrected.

ARTHUR BARCLAY.

29, Gloucester-road, Kensington, S.W.
May 19th, 1898.

THE LIFE-WORK OF WILLIAM MORRIS.

I notice in the able paper by Mr. F. S. Ellis, in the *Journal* of this week, on "The Life-Work of William Morris," that mention is made of the "Peterhouse carpets" as having been designed by him. As William Morris did sufficient fine original work of his own, his memory needs no inaccurate claim for work which he did not do. I, therefore, wish to say that it is incorrect to attribute to him any influence on the carpets for the combination and adjoining room of Peterhouse College, Cambridge. These carpets were made from designs drawn by my sister, Miss E. Julia Robinson, and sent out by me to Tanjore, where the carpets were made under my instructions. They were selected by the Rev. Dr.

Porter, Mr. Scott, and myself, at a time when I was intimately associated with this industry, with which I have long ceased to have any connection.

VINCENT J. ROBINSON.

Hopedene, Felday, Dorking.
28th May, 1898.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JUNE 6...Engineers, in the Theatre of the United Service Institution, Whitehall, S.W., 7½ p.m. Mr. E. A. Harman, "Gas Works Machinery."

Chemical Industry (London Section), Burlington-house, W., 8 p.m. Professor V. B. Lewes, "The Conditions existing in Acetylene Generators."

Surveyors, 12, Great George-street, S.W., 3 p.m. Annual General Meeting.

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Poulett Weatherley, "Circumnavigation of Lake Bangweulu."

Actuaries, Staples-inn-hall, Holborn, 5 p.m. Annual Meeting.

TUESDAY, JUNE 7...Royal Institution, Albemarle-street, W., 3 p.m. Prof. S. H. Butcher, "Literary Criticism in Greece." (Lecture II.)

Central Chamber of Agriculture (at the House of the Society of Arts), 11 a.m.

Biblical Archaeology, 37, Great Russell-street, W.C., 8 p.m.

Zoological, 3, Hanover-square, W., 8½ p.m. 1. Mr. L. A. Borradaile, "Some Crustaceans from the South Pacific."—Part II. *Macrura anomala*. 2. Mr. Arthur E. Shipley, "Report on the Gephyrea collected by Mr. J. Stanley Gardiner at Rotum and Funafuti." 3. Mr. G. A. Boulenger, "Fourth Report on Additions to the Batrachian Collection in the Natural History Museum."

WEDNESDAY, JUNE 8...Geological, Burlington-house, W., 8 p.m. 1. Mr. C. Dawson, "The Discovery of Natural Gas in East Sussex." 2. Mr. J. T. Hewitt, "Note on Natural Gas at Heathfield Station, Sussex." 3. Mr. A. O. Shrubsole, "Some High-level Gravels in Berkshire and Oxfordshire."

4. Mr. G. F. Franks and Prof. J. B. Harrison, "The *Globigerina*-Marls of Barbados," with an Appendix on the "Foraminifera" by Mr. F. Chapman.

Royal Literary Fund, 7, Adelphi-terrace, W.C., 3 p.m.

United Service Institution, Whitehall, S.W., 3½ p.m. Colonel Henderson, "Strategy and its Teaching."

Royal Society of Literature, 20, Hanover-square, W., 8½ p.m. Dr. J. W. Knipe, "The Development of Literary Criticism in England."

THURSDAY, JUNE 9...Royal, Burlington-house, W., 4½ p.m. Antiquaries, Burlington-house, W., 8½ p.m.

Royal Institution, Albemarle-street, W., 3 p.m. Dr. E. Klein, "Modern Methods and their Achievements in Bacteriology." (Lecture II.)

Mathematical, 22, Albemarle-street, W., 8 p.m.

FRIDAY, JUNE 10...United Service Institution, Whitehall, S.W., 3 p.m. Major Sir R. A. Colleton, "Training of a Battalion in the Attack."

Royal Institution, Albemarle-street, W., 8 p.m. Weekly Meeting. 9 p.m. Lord Rayleigh, "Some Experiments with the Telephone."

Astronomical, Burlington-house, W., 8 p.m.

Physical, Chemical Society's Rooms, Burlington-house, W., 5 p.m.

SATURDAY, JUNE 11...Royal Institution, Albemarle-street, W., 3 p.m. Dr. R. Caton, "The Temples and Ritual of Asclepius at Epidamum and Athens." (Lecture II.)

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FRIDAY, JUNE 10, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.

CONVERSAZIONE.

The Society's *Conversazione* will take place at the Natural History Museum, Cromwell-road, S.W. (by permission of the Trustees of the British Museum), on Wednesday, 22nd June. The reception by Major-General Sir Owen Tudor Burne, G.C.I.E., K.C.S.I., Chairman, and the other members of the Council will commence at 9 p.m.

The following portions of the Museum will be open:—On the Ground Floor—the Central Hall, British Saloon, and Bird Gallery; on the First Floor—the East and West Corridors.

A selection of music will be performed by the Band of the Royal Marine Light Infantry in the Central Hall, and by the Red Hungarian Band in the Bird Gallery, commencing at 9 o'clock.

Each member is entitled to a card for himself (which will not be transferable), and a card for a lady. In addition to this, a limited number of tickets will be sold to members of the Society, or to persons introduced by a member, at the price of 5s. each, if purchased before the date of the *Conversazione*. On that day the price will be raised to 7s. 6d.

These tickets will only be supplied to persons presenting members' vouchers (which can be obtained from the Secretary) or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman, and must be signed by the member applying for it.

Light refreshments (tea, coffee, ices, claret cup, &c.) will be supplied.

The entrance to the Museum is in the Cromwell-road. Carriages must enter the

grounds by the east gate and leave by the west gate. The cards must be given up on entering the Museum.

Visitors arriving or leaving by either of the Metropolitan Railways will be allowed the use of the District Company's Subway, which leads from the South Kensington Railway Station direct into the grounds of the Museum.

Fuller particulars as to the musical and other arrangements will be given in the Programmes which will be distributed on the evening.

The cards of invitation are now in course of issue.

Proceedings of the Society.

FOREIGN & COLONIAL SECTION.

Tuesday afternoon, May 24, Sir CHARLES MALCOLM KENNEDY, K.C.M.G., C.B., in the chair.

The paper read was—

THE GOLDFIELDS OF BRITISH COLUMBIA AND THE KLONDIKE.

By WILLIAM HAMILTON MERRITT, F.G.S.,
Assoc. R.S.M. &c.

It might be said, with reason, that the actual output of gold at present in Western Canada would hardly justify the time of your Society being taken up with a description of gold-fields, the production of which is small compared with many others in the world. Last year's output of gold from British Columbia did not much exceed the sum of £500,000, and we may add some £500,000 for the yield in the Yukon district in the north-west territories, making £1,000,000 (one million pounds) in all. This total yield does not much exceed that of the single state of Montana immediately south of our boundary line, or of South Dakota still further south; and it is not one half of the yield of the States of Colorado or California, which are also on the Pacific slope.

It is rather on the immense possibilities of the western mountain ranges of British North America that I would dwell, than on the greatness of the present operations, though in full justice to the increase in output in the past two or three years they must be considered as little short of remarkable.

Let us turn to a map of North America. We

see that for some 1,300 miles the great western mountain ranges traverse the United States after taking their rise in Mexico to the south. We then note that they continue through British territory for some 1,500 miles until they reach the shores of the Arctic. The distance from Rossland, in British Columbia, just north of the international boundary line, to Klondike in the Yukon district, in the north west territories of Canada, is some 1,300 miles.

It may be claimed that mere acreage counts for little from a mining point of view, and that miles of mountain ranges may mean nothing more than scenery. In this case, however, it has actually been found, in a general way, that wherever these ranges have been carefully prospected, from mines worked in Mexico in the south to Klondike in the far north, they have yielded metalliferous material of value.

We find that the geological formation and general features are, broadly speaking, identical in the north and in the south, and that the same conditions favourable to the formation of mineral deposits exist in the north as are found in the United States to the south, where work in developed mining camps has opened up immensely remunerative mining industries.

Figures speak more forcibly than mere generalities, and though they are held to be rather dry, I shall trespass upon your patience by giving you the following yield in gold of those States which are traversed by the western mountain ranges:—

1894.			1895.	
State.	Fine ozs.	Value.	Fine ozs.	Value.
Montana	137,135	£ 795,900	198,405	£ 843,000
Idaho	111,687	475,000	86,088	366,100
South Dakota	187,122	795,700	187,187	796,100
Utah	54,570	232,100	66,419	282,500
Nevada	59,051	251,100	75,088	313,000
Colorado ..	513,571	2,184,400	643,634	3,737,000
New Mexico.	40,128	170,600	23,810	101,200
Arizona	96,313	409,600	95,072	430,430
California ..	670,636	2,852,500	722,171	3,071,700
Alaska	62,047	263,900	78,140	332,500

Or from these ten States there was a total yield in 1894 of 1,982,260 ozs., of a value of £8,430,800; in 1895 of 2,175,014 ozs., of a value of £8,911,130; in 1896 a total yield of some 2,500,000 ozs., of a value of over £10,000,000; and in 1897 some 2,600,000 ozs., of a value of about £11,000,000.

As a further instance of the highly mineralised character of these great western zones, I will give further figures showing the yield in the United States of the western mountain ranges in gold, silver, copper, lead, and mercury in the above-mentioned ten States, in order to lay still further stress upon the undoubted possibilities of the same metalliferous ranges in their northern extension through a still larger distance than that which is yielding such vast wealth each year in its southern part.

VALUE OF YIELD (IN DOLLARS) IN 1895.

	Gold.	Silver.	Copper.	Lead.	Mercury.
	Dols.	Dols.	Dols.	Dols.	Dols.
Montana	4,101,400	22,715,600	19,017,215	607,724	—
Idaho	1,779,600	4,021,710	142,591	1,961,556	—
South Dakota	3,869,500	205,960	—	—	—
Utah	1,373,000	9,655,720	218,470	1,940,910	—
Nevada	1,552,200	1,236,290	—	164,146	—
Colorado	13,305,100	30,252,600	607,924	2,913,108	—
New Mexico	492,200	898,300	21,832	188,480	—
Arizona	1,965,300	1,275,990	4,795,355	127,286	—
California	14,928,600	845,180	21,833	58,838	1,334,475
Alaska	1,615,300	86,880	—	—	—
Total	44,982,200	71,194,320	24,825,220	7,962,048	1,334,479

The grand total of the above is 150,298,267 dols.

It is not my intention in this paper to touch out that even at the low price of silver the value of the output of that metal in British Columbia has exceeded the value of the gold on other metalliferous substances than gold, but I cannot resist the temptation of pointing

output for the past two years, and that the output of copper and lead is increasing by leaps and bounds. Mercury also will play its part, and altogether I believe it will not be found that I am departing from facts when I venture to predict that the day will come when the general metalliferous output of the western

portion of British North America will rival the enormous stream of yearly wealth which pours forth from the mines on the Pacific slope in the United States, to which I have just alluded.

The following Tables of the yield of British Columbia speak for themselves:—

AMOUNT AND VALUE OF MATERIALS PRODUCED IN 1896 AND 1897.

		1896.		1897.		Increase.
		Quantity.	Value.	Quantity.	Value.	
			Dols.		Dols.	Pcr cent.
Gold, placer ..	Ounces	27,201	544,026	25,676	513,520	..
Gold, lode	Ounces	62,259	1,244,180	106,141	2,122,820	70
Silver.....	Ounces	3,135,343	2,100,689	5,472,971	3,272,836	75
Copper.....	Pounds	3,818,556	190,926	5,325,180	266,258	40
Lead.....	Pounds	24,199,977	721,384	38,841,135	1,390,517	65
Coal.....	Tons (2,240 lbs.)	894,882	2,688,666	882,854	2,648,562	..
Coke.....	Tons (2,240 lbs.)	615	3,975	17,832	89,155	..
Other materials	.....	..	15,000	..	151,600	..
			7,507,946		10,455,268	

The great development in lode mining began about 1893, and the rapid progress made since

that year is shown by the following Table, which gives the output of the lode mines for 6 years:—

Year.	Gold fine ounces.	Silver fine ounces.	Copper pounds.	Lead pounds.	Total Value.
					Dols.
1892.....	1,170	77,000	..	808,420	99,999
1893.....	6,252	227,000	..	2,135,023	297,400
1894.....	..	746,379	324,680	5,662,523	781,342
1895.....	39,264	1,496,522	952,840	16,475,464	2,342,397
1896.....	62,259	3,135,343	3,818,556	24,199,997	4,257,179
1897.....	106,141	5,472,971	5,325,180	38,841,135	7,052,431

GOLD.

With regard to gold alone. Years ago, as the result of his geological investigation in British Columbia, it was pointed out by Dr. G. M. Dawson that almost every stream in the province carried more or less gold.

At the present moment the localities that are receiving the greatest amount of attention are the Rossland Camp, near the international boundary line in British Columbia, in the south, and Klondike, near the Arctic circle in the north-west territories, in the north.

Strung out between them are goldfields here and there all the way—Lilloet, Cariboo, Cassiar, and Yukon. Though it is not strictly correct to say there is gold everywhere, yet it must be said that from the international boundary to the Arctic, gold is found occurring here and there all the way, enough to justify

one in believing that there will be no general district that will not be a producer.

The gold-mining industry of nearly every country has started with the discovery of placer-gold, and British Columbia has been no exception to this rule.

The great quartz-mining industries in Colorado, California, South Dakota, &c., on these metalliferous ranges to the south, have succeeded placer discoveries, as in Australia and most other gold-producing countries. In the notes regarding the goldfields of Western Canada, which I shall bring to your attention, I therefore purpose first to treat of some of the facts connected with the discovery and operations of the placers, and afterwards to treat of the lode mining which has succeeded them, and which is only just beginning to assume importance.

PLACERS.

It was not long after the great placer excitement in 1849, in California, that the discoveries in British Columbia first received attention. It is reported that the first actual discovery in the province was made by an Indian woman in 1851 on the beach at Gold Harbour on the west coast of Queen Charlotte Islands. A slight excitement ensued, and a couple of expeditions in 1852 realised a small yield from a 7-inch irregular quartz vein.

The first report of genuine placer gold is from the agent of the Hudson's Bay Company at Kamloops, who bought it from Indians. In 1857 some French Canadians and half-breeds found placer gold at Nicoamen, nine miles from the mouth of the Thompson River. Some 300 ounces passed through the hands of the Hudson's Bay Company. A rush from California then commenced, and between March and June, 1858, over 20,000 persons arrived at Victoria by sea from San Francisco.

The hardships of the first prospectors in almost every country are very severe, and the early pioneers of Cariboo suffered much the same privations that are now being experienced further north in the Klondike goldfield.

The laws of British Columbia relating to mines and minerals have been largely framed by men who were among the pioneers of the country, and in them the rights of the prospector are recognised better than in most countries. He can have what he finds and stakes off, and can kill game for his own use whenever he may need it, game laws and close seasons notwithstanding.

The status of the prospector in the west is well set forth in Shin's "Story of a Mine," in which he answers the question as to who will stand out in the days to come as the central figure in the story of the great west. He believes it will not be the sturdy "bull-whacker" who steered the prairie schooners across the "North American Desert," nor the picturesque "cow-boy" with all his dash and devilry, but the red-shirted prospector who will be looked back to as he who laid strong and deep the solid metal formation on which the great western world has grown.

The first work of "gold digging" was carried on on the bars of the lower Fraser River, especially between Hope and Yale. Hill's Bar, just below Yale, is reported to have yielded nearly a million dollars, and Emery Bar, lower down, perhaps half this amount. When the first miners began to ascend the

Fraser, the Indians of the coast, an inferior type of the noble red-man, became alarmed lest their country should be taken from them. They inaugurated a species of guerilla warfare, and, as one of the pioneers expressed it to me, "It was a very gruesome thing to paddle along the dark tree-clad sides of the rapid river, not knowing the moment when a savage would peep out from between the thick foliage, and an arrow from a bow, or slugs from a Hudson Bay musket would sing past your ears."

This same pioneer, Mr. Ed. Stout, of Yale, still carries the mark of an arrow through his wrist, and some slugs deeply embedded in the muscles of his chest. This state of things went on for some time until one morning the bodies of five miners were found in the little bay at Yale, and with them were the corpses of one or more Indians. At this the miners armed themselves, took over the hills past the great Canyon, and carried by storm the principal Indian village, sparing nothing and nobody. After this the natives succumbed to the inevitable.

In the year 1858 the output of gold started, and each month mounted up at a rapidly-increasing ratio—June, \$6,000; July, \$45,000; August, \$45,000; September, \$164,000; and October, \$283,000; or total for these five months of \$543,000. In 1859, both the miners who had pushed their way up the Fraser, and others who had worked north through interior routes, reached the Quesnelle River, and, in 1860, rich diggings were found on that river and on Antler Creek.

In 1861, Williams and Lightning Creeks, the richest in Cariboo, were discovered. The former is stated to have yielded \$19,000,000, and the latter \$10,000,000. In 1862, most of the other rich creeks were found. In this year a second influx commenced, owing to the rich finds in Williams and Lightning Creeks; and among the expeditions were a couple of parties overland from Eastern Canada via the Red River and Fort Quarry (Winnipeg), the Little Saskatchewan and Fort Ellis, the north branch of the Saskatchewan, Fort Carlton, Fort Pitt and Edmonton, Lake St. Ann, the Athabaska River, through the Rocky Mountains, to the upper part of the Fraser River and Tete Jaune Cache. At this latter place the parties divided, one going down the Fraser via Fort George and the upper canyons of the river to the mouth of the Quesnelle, and the other down the Thompson to Kamloops. The hardships of these parties were great, and six of them lost

their lives. The story, "Overland to Cariboo," is well told by Mrs. Archibald McNaughton, of Quesnelle Mouth, whose husband was one of the party which went down the Fraser.

The total yield of gold from Cariboo was some \$50,000,000, the largest years' yield being from 1863 to 1868, when there was an average output of over \$3,000,000 a year. The yield for the last three years is as follows—

	1895.	1896.	1897.
CARIBOO :—	Dols.	Dols.	Dols.
Barkerville District ..	81,000	82,900	65,000
Lightning Creek Dist..	40,700	53,000	25,000
Quesnelle Mouth Dist.	18,200	51,100	35,000
Keithley Creek Dist..	142,500	197,050	200,000
LILLOOET	40,663	33,665	37,480
CASSIAR	—	21,000	37,060

As an example of some of the old-day yields in Cariboo we might quote the yields on some claims on Williams and Lightning Creeks, which were the two richest creeks in the district.

According to the reports of the Gold Commissioner of the district, Williams Creek and its tributaries yielded over \$19,000,000,

and Lightning Creek and its tributaries some \$10,000,000, as has already been noted. In the Lillooet district Cayoosh Creek was most productive, and yielded nearly a million dollars.

On Williams Creek the Aurora and Cameron claims each yielded some \$800,000, a few other claims over half a million of dollars, and a number from \$200,000 to \$300,000; 108 claims yielding \$17,355,000, being some \$160,000, on an average, per claim.

On the Dillar claim, on April 13th, 1863, three men washed up 104 lbs. (2,080 ozs.) in the afternoon.

The Gold Commissioner, Mr. Bowron, states that he has seen 1,000 ozs. washed up in the Aurora claim for three days rim drifting underground.

On Lightning Creek the best week's wash-ups were in the Vuncan claim, 400 odd ounces; in the Vancouver, 603 ozs.; in the Victoria, 964 ozs., and higher up stream, in the Van Winkle, 1,570 ozs. from 13 sets of timber, or 455 square feet (viz., about $3\frac{1}{2}$ ozs. per square foot of bed rock, or 120 ozs. per set), and in the South Wales, 1,000 ozs. for the week ending October 9th, 1871.

The best month's yield in the Van Winkle claim gave :—

Product for week ending 5th September, 1875	....	858 $\frac{1}{2}$ ozs.	....	\$15,169.69
" " 12th " "	....	1,251 " "	....	22,106.67
" " 19th " "	....	1,570 $\frac{1}{2}$ " "	....	27,749.87
" " 26th " "	....	893 $\frac{1}{2}$ " "	....	15,790.96
" to September 30th (4 days), " "	....	495 $\frac{1}{2}$ " "	....	754.64
Total for September, 1875.....				\$89,571.83

These figures are from the original books of the Van Winkle Company, in the possession of the Gold Commissioner.

The best pan (about 20 lbs.) on record on the Creek was got from favourable crevices by Harry Jones in the Van Winkle, 101 ozs. Other big pans on record are 72 ozs., and numbers of 30 ozs. upwards were obtained.

There is placer gold in nearly every part of the province, and among the discoveries outside of Cariboo the following may be noted.

In 1863, in East Kootenay, Wild Horse Creek was found to be rich. This creek is still worked, a plant for hydraulic mining has been installed by an English company, and good results are expected. In 1864, Leech River, in the southern part of Vancouver Island, yielded some gold. In 1865, the big bend of the Columbia was found to have rich

placers, and there was a rush there in the following year.

From 1869 to 1871 the feeding creeks of the Omenica branch of the Peace River were worked, but abandoned in 1873 for the richer placers discovered in the previous year in the Cassiar district, where the McDame's Creek in the Stickene district is still worked. These Cassiar mines carried the miners into the Yukon, and further north, in 1880; and, as far back as 1886, coarse gold was found on the Forty-mile Creek.

From 1879, for the next seventeen years, Cayoosh Creek, in the Lillooet district, yielded over \$1,000,000 from its placer gold.

In 1885, Granite Creek, in the Similkameen district, was found to have rich placers, and a good deal of platinum was found as well as gold.

Lately, in the north-west territories, the tributaries of the Yukon River, especially the Klondike River, with the Bonanza, Eldorado, and other creeks, were explored in 1896, and bid fair to establish an unprecedented excitement and influx of adventurers.

BRITISH COLUMBIA.—YIELD OF PLACER GOLD
PER YEAR TO DATE.

	Dols.		Dols.
1858	705,000	1878	1,275,204
1859	1,615,070	1879	1,290,058
1860	2,228,543	1880	1,013,827
1861	2,666,118	1881	1,046,737
1862	2,656,903	1882	954,085
1863	3,913,563	1883	794,252
1864	3,735,850	1884	736,165
1865	3,491,205	1885	713,738
1866	2,662,106	1886	903,651
1867	2,480,868	1887	693,709
1868	3,372,972	1888	616,731
1869	1,774,978	1889	588,923
1870	1,336,956	1890	490,435
1871	1,799,440	1891	429,811
1872	1,610,972	1892	399,526
1873	1,305,749	1893	356,131
1874	1,844,618	1894	405,516
1875	2,474,004	1895	481,683
1876	1,786,648	1896	544,026
1877	1,608,182	1897	513,520

Total.. \$59,317,437

PRESENT PLACER OPERATIONS.—CARIBOO
DISTRICT.

The most important operations in placer mining in the province of British Columbia are being carried out in the Cariboo district. The developments are chiefly in the direction of hydraulic placer mining, and some of the enterprises give promise of very important outputs of gold.

The largest operations are carried on by the Cariboo Hydraulic Company, which is working an ancient river channel, occurring at a higher level than the present Quesnelle River, and cutting it. This company produced some £26,000 in 1896 and some £27,000 in 1897. The face operated on is about 200 feet high, and underlying that there is from 150 feet to 100 feet of rich gravel still to be worked. As the old channel has been uncovered for some 1,600 feet of its width, and was some 700 feet in width of gravel, the immediate future possibilities of this claim are very great. In fact

those interested have good reason for the belief that it will prove one of the greatest hydraulic mines in the world. The reason that this mine, and many other gravel benches in the province are not worked to their full capacity, is scarcity of water. Enormous amounts of water come down in the early summer when the snow is melting in the mountains and makes torrents in every gulch and depression; then so soon as frost comes again, there is no water coming from the mountains, and creeks that were raging torrents in the summer can be stepped across in the autumn and winter. The duration of water for hydraulic placer operations is therefore very short in nearly every case where the source of supply is not from some river or very large lake.

Extensive dams are therefore necessary to make immense reservoirs or to raise the level and restrain the outflow of mountain lakes, and ditches often have to be made for many miles to bring the water on to gravel banks. In the case of the Cariboo Hydraulic Company's mine, to which reference has just been made, there are 21 miles of ditches, one ditch being 11 miles in length, with a grade of 6 feet to the mile, and a cross-section showing a depth of 3 feet and a width of 13 feet and 7 feet on top and bottom respectively. A ditch such as this carries about 3,000 miners inches (4,500 cubic feet per miner). The largest giants or monitors at the Cariboo mine have nozzles of 10 inches diameter, and steel pipe, varying from 48 inches to 30 inches to 24 inches and finally to 22 inches, brings the water to the monitors from the ditches. The sluices are 5 feet wide, and 2 feet deep, and from 75 to 80 lbs. of mercury are used per day in the one large pit when two monitors are running. Since work commenced in 1894 some £70,000 have been taken from this mine, all of which has gone into operating and construction expenses. This will serve as an example of an actively prosecuted hydraulic placer mining operation, of which there are a number of smaller plants in Cariboo district, both in the Quesnelle, the Horse-fly, and the Barkerville district.

Hydraulic elevators are being used at the Ward mine, on the Horse-fly, and the same method of raising the gravels will be followed in working the lower ground of Williams Creek by the Cariboo Gold Mining Company. The latter company are installing two Campbell hydraulic elevators, which will each raise some 1,200 cubic yards of gravel per 24 hours with 600 miners inches (900 cubic feet of water per

minute). A drainage tunnel, about 3,000 feet in length, drains the foot of the elevator shafts; and two sluice boxes, each 4 feet by 4 feet, with riffle blocks, situated 88 feet above the elevator, will carry off the raised gravel. Fourteen miles of ditches have been constructed.

A good deal of work has been done in trying to bottom the lower ground of rivers which have paid handsomely in Cariboo. In this class of operation, the most important are the Willow River and the Slough Creek mining operations. These are carried on on modern principles by locating the exact position and depth of the old channel by hydraulic boring machines, and then sinking bed-rock shafts in which heavy pumps are placed, and drifts then run at the proper level to catch the old channel.

Another type of placer work being carried on in the Cariboo and Lillooet districts is exemplified by the operations on the Quesnelle River, where the river bed will be temporarily laid bare by means of a dam. In Lillooet a company proposes to divert the course of the Bridge River by means of a tunnel, and thereby get at the river bed.

Dredging for gold in these northern districts has been carried on in several of the rivers, notably the Fraser and the Quesnelle in British Columbia, and in the Saskatchewan in the north-west territories. Operations of this character are being carried on at this present time in some of the localities.

The general experience has been similar to that of the western United States, where dredging has not been satisfactory from a commercial point of view. In view, however, of the immense improvements made in New Zealand in the type of dredges used for raising and saving the gold, and disposing of the large boulders generally associated with it, a number of new dredging schemes are constantly on foot, and it is altogether probable that profitable dredging will be inaugurated in the province.

THE CASSIAR DISTRICT.

This district is the connecting link between Cariboo and Yukon. Placer gold has been mined there for many years. It commenced on the bars of the Stikine River and later the Dease, Thibert, and McDame Creeks gave satisfactory yield, over a million pounds worth of gold having been taken from this district in the last 25 years.

McDame's Creek has been worked up to the last few years. It has produced from £10,000

down to £4,000 for the last ten years, but may now be said to be worked out. As the country opens up there is but little question but that richer placer deposits will be found in the Cassiar district than have yet been discovered.

THE OMENICA DISTRICT.

This district may be said to be the northern end of the Cariboo district, and has great possibilities. The known yield, so far, has been unimportant.

KLONDIKE.

The most recent goldfield in western Canada, to which men are rushing in thousands, coming from almost every part of the world, is that known by the name of Klondike, in the Yukon district in the north-west territories of Canada. This district is tributary to the great Yukon River and covers, in a general way, the territory south of the Arctic Ocean and between the Mackenzie River and the boundary between Alaska, or United States territory, and Canada. Gold has been known on the Yukon River since 1864, and has been worked intermittently since 1873. The Klondike is one of the rivers which runs into the upper portion of the Yukon River, and Bonanza, Eldorado, and other creeks whose names are becoming familiar to all the world, are mountain streams flowing down from golden-ribbed ranges into the Klondike River. These latter were discovered to carry coarse gold in 1896. It has taken a good many years to reach the rich fountain head of all the gold which has been found scattered far down the great Yukon River.

The official guide prepared by Mr. Wm. Ogilvie for the Dominion Government gives much information relating to discoveries and recent developments in this district, which I shall quote from.

In 1847, Fort Yukon was established at the mouth of the Porcupine River (now in Alaska), and in 1848, Fort Selkirk was founded at the confluence of the Pelly and Lewes Rivers, both by the Hudson Bay Company. Early in the seventies miners found that bars on the Yukon carried gold, and as they worked out the lower bars, carrying fine gold, and ascended the stream they found coarser gold and richer bars. In 1874, traders began to find their way up the river to establish posts in Alaskan territory, and in 1882 a number of miners entered the country by the Dyea Pass; previously they had come up the Yukon River from its mouth. The hardships of the pioneer

miners were very great. I have met men who had worked on the placers along the Yukon, but who had left the country on account of the unbearable cold, though they had made good wages. Still the miners pushed on up the great river, further on each year, getting heavier gold on the upper bars, until in 1886 coarse gold was found on the Forty-mile River, the first tributary of the Yukon which had been found to yield it. The news spread far and wide, and from then until the richer Klondike river was struck, there has been active prospecting on other tributary rivers and creeks. It is stated that it is probable that in Canadian Yukon territory we have not less than 1,400 miles of stream, upon all of which gold can be found. For example, far above the Forty-mile and the Klondike Rivers, between Big Salmon River and Teslin Lake, a party of four miners took \$6,000 from Cassiar bar in thirty days in 1886. The mining of the deep ground on Forty-mile River and on the bars on the Yukon and some tributary streams, such as the Stewart River, continued giving very satisfactory yields during the short seasons until 1896, when Bonanza and Eldorado creeks were discovered. A man named George W. Carmack first "struck it rich" on these creeks, and they were soon staked off. Last year's yield has made them famous the world over. Indian Creek, which flows into the Yukon some 25 miles above the Klondike River, has three creeks (Dominion, Sulphur, and Quartz) which yield handsomely, as high as \$9.0 per pan. They have been staked off and partially prospected. Stewart River is viewed very favourably as a prospecting ground, owing to the fact that when first mined on, its bars yielded as high as \$30.0 to \$100.0 a day, worked by a rocker. It is reasonably expected that creeks feeding into it will be found to be rich. Other rivers and creeks give indications which lead Mr. Ogilvie to believe some 125,000 square miles of the country is gold-bearing. The Klondike deposits are said to be ordinary typical placers. The gold-bearing gravel is from 2½ to 5 feet deep, and the gold is found in the bed-rock from 6 to 18 inches. Above the gravel is some 15 feet of mud or muck. In some places the bed-rock is a mica-schist, in others a quartz-schist mixed with slate. No quartz veins of any value have so far been discovered, but stringers of quartz carrying gold have been found in the bed-rock. An eminent mining engineer, in writing to the *Engineering and Mining Journal* of New York from Dawson

City, north-west territories, March 4th, says: "This work up here is the worst in the world, and cannot be dignified by the name of mining. The climate is terrible, but there is plenty of gold and work for years in these regions. At present labour is 6s. per hour; everything can be averaged up at about 6s. per lb. Food is scarce, but people will not die from starvation this year, though there is a pretty narrow escape from it. Cigars (1½d. and 2½d. kind) are 2s.; the worst liquor in the world 2s. a glass. They figure on an output of £3,000,000 this year, but the more conservative put it at £2,000,000. I think you will see an awful shrinkage on the known output if the Canadian Government forces the payment of 10 per cent. royalty on the output as proposed."

In 1897, up to December 13th, there were on record 3,800 claims in the office of the Gold Commissioner for the Yukon district, 65 of which were quartz claims. The estimated yield of gold in 1897 was about £500,000.

LODE OR VEIN MINING.

We now come to the consideration of the goldfields which are producing the noble metal from the solid rock, from veins or lodes. As has already been pointed out in the Table which shows the advance in output in British Columbia in lode-mining since 1892, the industry is very new, but it has increased with astonishing rapidity in the last few years.

As already noted, in most gold-producing countries placer development has preceded the more permanent industry of continuing the extraction of the precious metal from some of the veins which have supplied the material to make up the placers. It is only natural, therefore, that in the placer districts men soon commence to hunt in the mountains for the veins which supplied the rich placers in the valleys below. Thus it has been the case that both in Cariboo, Lillooet, and East Kootenay districts, there have been "quartz excitements" from time to time, and we shall no doubt have the same thing occurring in the Klondike in the near future.

In 1877 and 1878, a good deal of work was done on the veins in Cariboo, but the enormous difficulties of transport and low grade, or refractory character, of the comparatively few veins exploited made the effort premature. In these northern placer countries, prospecting for quartz veins is very difficult, owing to the enormous amount of gravel, or *débris*, from the easily disintegrated schists. "Float"

from quartz veins is everywhere, but the veins are seldom seen outcropping on the mountain sides, though constantly met with when drifting is done on, or in, the bed-rock in the placer workings.

The general geological features of most of the Northern British Columbia districts is that comparatively soft schists interlaced with auriferous quartz seams have been worn down to form the placers. Regular and well-defined strong veins are found, but the general characteristic of the quartz is its great irregularity and abundance in the schists. Therefore, conditions occur where nature has been able to mill down vast areas of this sort of formation to form rich placers when man could not profitably accomplish the extraction of the gold from the matrix it occurs in.

Another curious anomaly found in the northern placer countries is that many of the veins instead of carrying the majority of their auriferous value as free gold have it associated with pyrites, and only a comparatively small percentage can be extracted by the ordinary process of milling and amalgamation. Even in these cases it has been found that the gold is satisfactorily extracted by cyanide or by chlorination; trials made on some of the ores so far have shown that the former process is the more economical.

However, there is no question but that strong quartz veins will be found, or some of those already found will be exploited in the near future in these northern districts. Also that instances will be found where it will be profitable to mine and treat the entire belt of quartz and schists where the irregular condition above alluded to occurs.

The great problem to be solved in connection with the vein development of these northern districts is the question of transportation, or railways, and it is gratifying to note that both the Dominion and the British Columbian Governments have adopted a policy which will lead to the opening up of these districts in the near future. Once railway communication is pushed into Northern British Columbia, gold quartz mining will, with leaps and bounds, forge to the front as the most important industry in Northern British Columbia.

The gold discoveries, next in importance to the above-mentioned placers, were those in the West Kootenay district, in the vicinity of Rossland. At the present moment, the importance of the development accomplished on the refractory or smelting gold ores greatly exceeds that on the free-milling variety, therefore we

shall first consider some of the facts in connection with the smelting gold ores.

SMELTING ORES.

The gold ore of the Rossland district is a cupriferous magnetic iron pyrites, mineralogically known as cuprous-pyrrhotite. The decomposition of this gives rise to a red soil, so that the mountain in which the largest deposits are found is known as "The Red Mountain." Romance hath it that a seeress in the south told some prospectors of this mountain, where great riches in gold could be had, and that they found the mountain and found it heavily mineralised; but as they could see no visible gold, or pan out a long "tail" of it, they returned sorely disappointed. History states that large outcrops of galena were known on Kootenay Lake, but as they ran low in silver, they lay undeveloped until, in 1887 or 1888, the Hall Brothers, who are half-breeds, ran across the large outcrop of the "Silver King," a high grade silver-copper ore. This created an excitement, and prospectors from the south came over the international borderline in considerable numbers. In 1889, Joseph Bourgeois located the first claim in the Rossland gold district, the "Lily May." The same man located the "Center Star" and "War Eagle" on the Red Mountain, while his partner, J. Morris, staked the "Virginia" and "Idaho." These men allowed Mr. E. E. Topping to stake the "Le Roi," which they also discovered, on his paying the expense of recording their claims. Thus it may be said that the mine that up to the present has proved the most valuable lode mine in British Columbia was virtually sold for "a mess of pottage." The man who has had more to do with the preliminary development of the Red Mountain than any other man is Mr. Oliver Durant, who first managed the Le Roi and subsequently purchased the next mine, the Center Star, which he is now developing.

This group of mines on the Red Mountain at Rossland are of peculiar interest. There is an amply verified adage that "Gold is where you find it," and, like the famous gold-bearing conglomerates of Africa, the Red Mountain gold veins are without a parallel. The ore is virtually identical with the nickel ore found at Sudbury, in Ontario, but which carries only a small amount of gold. The form in which the two occur, however, is very different. While both occur in very basic rocks, the Sudbury ore being associated with a diorite and the Red Mountain ore with a Gabbro, yet the

Sudbury ore occurs in masses and the Red Mountain ore in well defined strong fissure veins often with a banded central streak of calcite. To give an example of the strength of the fissure traversing the Le Roi, Center Star, &c., it might be noted that in places in the Le Roi mine the ore body has been extracted across a width as great as 30 feet, and that the average width of stoped ore, down to the 600 foot level, is 12 feet. At the time of the discovery of the Red Mountain, if one versed in Canadian ore were shown a piece of the pyrrhotite from the outcrop of the Le Roi, he would probably have expressed an opinion that it might be worth assaying for nickel, but that it would be hopeless to expect to find more than a trace of gold. Yet the smelter returns have given a steady yield from £4 to £6 per ton in gold for the last couple of years, with from 1 to 3 per cent. of copper and a couple of ounces of silver. There is a very small proportion of free gold, the values being entirely extracted by smelting. The only gold smelter at present running in Canada is operated by the Canadian Pacific Railway Company at Traill on the Columbia River, just below the town of Rossland. The product is a gold-copper matte, which is exported for the final extraction of the gold, copper, and silver, chiefly to Butte, Montana.

To the west of Rossland, large areas of greenstone rocks contain a large amount of mineralisation, especially along the lines of contact with limestone bands. This condition of things is well developed in the Boundary Creek district, and particularly in the vicinity of Greenwood Camp. There is every reason to believe that large bodies of copper-gold ore will be developed, but most of the finds so far are of a low grade, and much interest is being taken in treating the ores to extract the values. The Canadian Pacific Railway is soon to build a branch line from Rossland to Penticton, at the foot of Okanagan, which will pass through the Boundary district.

FREE MILLING GOLD ORES.

The free-milling ores of British Columbia have, as yet, not been developed to any extent. At Camp McKinney, in the southern O'Kanagan, a fine vein, averaging about 4 feet in width, has been mined for four years. The present small ten stamp mill is to be enlarged. The ore runs some \$17.00 in gold values, chiefly obtainable on the plates.

The Fairview camp, some 25 miles west of the above place, has also yielded good, free-

milling ore. At this place there are several systems of veins, the strongest running in a band of schistose quartzite, for a couple of miles, beside a great granite mass. High grade ore has also been mined in veins found in the granite.

The ore shoots in this camp, while carrying values from \$6.00 to \$30.00 have so far not been found very liberally distributed, but mining development on a more extended scale than hitherto attempted, will probably open up areas of pay ore which have not yet been discovered. Two stamp mills have so far been erected in this locality, one ten and the other sixteen stamps.

In the West Kootenay district, near Nelson, a vein has been worked at the "Poorman mine" since 1890, therefore it can claim to be the pioneer free-milling enterprise of southern British Columbia. The value of the ore is said to be some \$16.00, and the ore is milled in a ten-stamp mill, run by water power. Some £20,000 has been produced by this small mill. More recently, the Fern mine, in the same district, has yielded some 7½ dwt. from the plates of its ten-stamp mill, and 1½ dwt. from its concentrates, or a total value of 9 dwt.

Also, all reports from the Athabaska mine on Toad mountain are very encouraging, so that it can properly be said that while the developments thus far have not yet yielded such large returns from the free milling as from the smelting ores of southern British Columbia, yet there is every reason to expect a large and permanent gold-milling industry in many places in British Columbia.

Ultimately, there can be no question whatever about the fact that large operations on free-milling quartz, as well as smelting ores, will be carried on, but the policy of opening the country by railways has a very close connection with this, as well as all other classes of mining development. Only in very exceptional cases will satisfactory developments be sustained without railway communication, and on the other hand, the railway will inaugurate such immense mineral development that it will pay handsomely all interests connected with both enterprises, viz., the railway and the mineral interests. In this connection, it is gratifying to note that both of the great political parties appear to be a unit on this most important matter, and seem alive to the necessity of a vigorous policy to open up the great mineral belts by railway communication.

In conclusion, with regard to the general natural conditions affecting the mining in-

lustry in British Columbia, it can be stated most emphatically that they are, on the whole, remarkably favourable. There is ample timber throughout the whole country. As a rule, there is abundance of water, though in some parts of the dry belt in southern British Columbia water is scarce, and in the extreme north the shortness of the summer season makes the supply variable. The climate in the southern part of British Columbia, where the major part of the mining operations are now carried on, is delightful. In the valleys fruits of nearly every sort can be cultivated profusely, and, even as far north as the Peace River valley, cereals can be raised in abundance. A more healthy and vigorous class of humanity it would be difficult to find than those who are met with in the country, who have lived there for many years, and who in their own parlance are known as "old-timers."

The above facts, taken in consideration with the development which was pointed out in the first part of this paper, establish the enormous value of these great metalliferous ranges to the south in the United States, and lead to the inevitable conclusion that it is merely a question of search, development, and railway communication to make the province of British Columbia and the north-west portion of the north-west territories of Canada, one continuous, great mining camp for nearly 1,500 miles in length, and one of the greatest producers of the world's supply of gold, silver, copper, lead, and perhaps mercury.

DISCUSSION.

The CHAIRMAN, in proposing a vote of thanks to the reader of the paper, said:—It seems to me that the first impression on hearing Mr. Merritt's interesting and exhaustive paper is that it contains a very impartial and sober statement of the subject with which it deals. He is an authority on those questions as eminent as any person who has spoken or written on them; and in thanking him for his paper we may express our regret that he is unable to be present to-day. The Dominion of Canada is gold-producing from east to west, as well as from north to south. But it is to be borne in mind that these gold-producing districts are as yet imperfectly explored, and consequently imperfectly developed. In the first place, therefore, several cautions should be kept in view both by investors and by those who look after the interests of investors. A district may be said, truly, to be gold producing, but various points have to be considered in connection with proposed mining operations in it. A district as a whole may be rich

in gold, but it does not by any means follow that every part of it is so. It is quite uncertain what quality or quantity of ore may be found in any particular "claim." This ore may not be of sufficient value to defray working expenses. Reefs vary, not only in thickness but also in depth; and even when the lode runs on continuously, the quality may vary. Workings as yet have only in a few instances been carried on upon a large scale. Surface working and mining operations in the first stage are of value as far as they go, but they are not conclusive as to ultimate results. Care must be taken to ascertain that the titles to particular "claims" are valid. In addition to these matters of detail, it is to be remembered that in many localities in British North America there are difficulties of travelling and transport, besides natural disadvantages from the physical geography and climate of that part of the continent. Smelting and stamping works are much wanted. Great vicissitudes have attended the efforts of individuals: those who succeed give favourable accounts, which, as passed on by their hearers, become exaggerations; those who fail or suffer much hardship, dwell on the difficulties of the way and give a bad character of the land. On the other hand, the *Times* of the 4th and 11th instant, and the *Canadian Gazette* of the 5th and 12th instant, report lectures by Mr. William Ogilvie, of the Survey Department of Canada, in which he said that "of the 128,000 square miles comprising the Yukon district, 125,000 are more or less gold-bearing;" and that "hundreds of millions of dollars would be got out of the Yukon district during the next two or three generations." (*Times*, May 11, 1898.) It may be further remarked that while, as Mr. Ogilvie says, none of the quartz reef so far located have assayed very high, yet they are extensive. Mr. Merritt points out that the progress of chemical science is likely to prove an important factor in British North America, by bringing into use new processes, which will make practicable the working of lower quality ores. In course of time, therefore, working grounds which at present do not defray the expenses of mining operations, may become moderately remunerative. The owners of properties are apt to attach too high a value to them. The more prudent course is to take up mines which are so far developed that under ordinary conditions mining science warrants expectations of good results from the indications which they afford. A partially-opened mine which fulfils these conditions is a better investment than a mine which has been already fully worked. Mr. Merritt adverts to the case of the Le Roi mine, yet a mine of this position must stand dearer in the money market than one equal to it in real value, although not yet developed to the same extent. In regard to all mining operations in British North America it is important to note that there is no danger, such as that which exists in South Africa, from the presence of a large native population. The natives are not numerous and are not hostile. Great successes cannot reasonably be

expected at the commencement of operations. Knowledge of partially-explored districts has to be obtained, and experience must be acquired of the operations to be conducted over these areas. Discoveries are to be looked for. The location of the mother-lode Mr. Ogilvie says (*Canadian Gazette*, May 12th, 1898) has yet to be discovered. And over many portions of the vast territories of the Dominion of Canada there is, in the words of Mr. Bryce with regard to South Africa, the great natural excitement of opening up a perfectly new country with all its undeveloped and undefined possibilities. The promoters of development enterprises provide the means which are absolutely necessary for occupying new districts in British territories. Neglect effectively to occupy such localities has given rise to many serious international disputes. Accordingly, the promoters of these undertakings do not merely serve private or selfish interests. In making investments of this nature, which demand every good wish for substantial returns to the investors themselves, they likewise serve to a great extent important public interests, which advance and secure the welfare of the British colonial empire.

Mr. J. LOWLES, M.P., said he regretted not to have heard the whole of Mr. Merritt's paper, but when in Canada he heard nothing but good of him, both as an expert mining engineer, and as a man who was careful not to overstate his case, or speak extravagantly of the mineral resources of the country he had examined. Having seen with his own eyes something of the vast potentialities of this great auriferous region, he could say that he thought in that respect it was second to none of our great British colonies. It was true there were great drawbacks, and especially the rigorous character of the winter, which he could speak of from experience, having travelled over the Rockies in the snow a few months ago. He could only say that the way in which those marvellous animals, the cayuches, carried a load of 15 stone to an elevation of some 5,500 feet, over almost inaccessible paths, where an ordinary horse would have been of no use at all, was marvellous, and he felt very much inclined to bring one home with him as a memento of what the native animals could endure. On another occasion he had a journey of something over 150 miles from Ashcroft to a point on the Fraser river by sleigh, and when half way they were caught in a heavy snowstorm, and turned over into a drift where they had to remain five hours, and he feared at one time he should never see his home again. The pioneers of this industry had enormous difficulties to contend with. Not long ago he had the privilege in that room of paying his tribute to the great debt which the empire owed to its hardy sons, who went out with their lives in their hands to open up fresh territories, and provide wider fields for the profitable employment of labour, and he regarded these new discoveries as coming at a most opportune time, for anyone who studied figures must

see that, although there was a constant increase in our labouring population, the avenues for employment at home were getting narrower and narrower every day. He was sorry to say that, according to the Board of Trade returns, there was a tendency apparently, to import increasing quantities of manufactured goods from our Continental neighbours, so to practically cut the ground from under the feet of our artisan population at home. He therefore looked on these new developments as likely to give an outlet for surplus labour. It was also a hopeful sign that there seemed an increasing disposition on the part of emigrants to go to colonies under the British flag, rather than to territories under the flag of other nations, a disposition which ought to be encouraged; and papers such as this of Mr. Merritt could not fail to attract intending emigrants to this new field, where such vast potentialities existed. From all he had seen, he believed that as the systematic prospecting of these great auriferous areas went on, the capital of British investors would be attracted; and he thought if this were done with discretion, it would be a great advantage to have the security of the British flag and British laws, and that would all tend to the opening up and strengthening of the British Empire.

General CAMERON said he knew something about Canada, and could confirm all that had been said in the paper. In reference to some remarks of the previous speaker, he might point out that it was a misconception to speak of Canada as a country which was always covered with snow. Any mountainous country, the Alps, or Himalayas, or anywhere else, were not suitable for cross-country excursions in the winter season, but roads were being made in the region, and from Ashcroft there was a very good road, along which a stage coach ran as well as in England. But in winter, in a mountainous country, no matter what the latitude, there was sure to be snow, and communication must be difficult. The summer was superb, particularly in the southern parts of British Columbia, and there was everything to invite the settler. There was beautiful scenery, rich land, abundant minerals, fine grazing territory, and everything to make the place inviting, eminent so on the eastern slopes. On the western side you came across to the Pacific, and no doubt shortly the whole commerce of the eastern part of Asia would be coming across there, and be forwarded by the Canadian and Pacific line. His knowledge of Canada extended back to 1867, and not long after he ran some 600 miles of the boundary line westward to the Rocky Mountains when there was not a white inhabitant from Winnipeg and the lake system of Canada to the Rocky Mountains. Now the whole area was dotted over with towns and settlements, not only on the plains, where a man had simply to drive his plough and set out his crop, but in the mountains also civilisation was advancing as they were opened up by the railways. The photographs which had been placed

on the screen showed what an attractive country it was, in spite of the difficulties which no doubt must be encountered in the winter season. No doubt the winter temperature was low, but it was not unhealthy; he had camped out there in the open with the temperature at 40° below zero, due precaution being taken to wear suitable clothing. In 1872, he was out with a party of British engineers, with only canvas tents, but being properly clad, they were able to work in the open with the temperature of -50°, though an United States party, not so well prepared, had to retire into winter quarters, the Englishmen doing their work as well as their own. During the whole three years they lost only three men out of a large party, one death being accidental. With regard to mining, it had come to his knowledge that westward from the Rossland, extensive outcrop of rich gold and silver bearing quartz had been found. With regard to railway communication, the Canadian and Pacific line would connect Rossland with the Pacific, but there was a United States company trying to work in and out along the boundary line in what he thought was somewhat unfair competition. He did not see why a line should be subsidised to carry the ores away to be smelted in the United States, these ores ought to be treated in our own territory.

Captain ADAMS (Midway, British Columbia) said, as an acquaintance of Mr. Merritt, he was glad to be able to express his gratification at the accuracy of the information conveyed in the paper, so well illustrated by the typical views of the scenery. He might point out that in the early stages of mining operations snow was found of great advantage. On many of these mountain roads a horse could only carry about 50 lbs., and it was therefore very difficult to get the ore away and to get up supplies; but in the winter time a ton of ore could be wrapped up in raw hide and one horse would take it down the mountain on the snow; sometimes he sat down on it and had a slide, but at any rate he got it down, and thus the cost of transport was much reduced. In a little while people got used to the conditions, and managed to work in spite of the climate. He had been operating a mine which was closed up in November with snow slides, but he found men willing to go up to a height of 7,000 feet to blast out the rocks, and they built a cabin in the mouth of the tunnel, and there they lived all winter working the mine. They got used to it, and in time seemed to like it; there was a romance about it, and the hope of immense success seemed to lead them on. As to railways, it was of great importance to encourage transport, because there were immense bodies of low grade ore which could not be worked except under the most favourable conditions. It was important that smelters should be built, and that railroads should come to them. They all appreciated the patriotic sentiment of having roads in their own country, but he had been connected for many years with a district

just on the boundary line, and he had given the settlement the name of Midway, as the fence was on the boundary line, and he hoped some day they might have a grand gathering there to bring about that reciprocity which they all hoped would eventually exist between the United States and Canada. The Americans had offered to build a railway there without a subsidy, but the Government were so patriotic that they said no, they would wait until the Canadian line came. That was a very beautiful sentiment, but some of them who were growing old thought they would just as soon make a little money before they died, by the aid of American railways, as leave it to future generations to make money from Canadian sources. They thought if people were willing to build railroads for nothing, they should not be too particular about the flag under which it ran. In conclusion, he said it was very pleasant to those engaged in these undertakings, to have them explained and made interesting in London, the centre of the financial world, because, after all, the capitalist was as necessary as the prospector; if not more so. It was well said that mines were made, not found, and money was needed to make them.

General CAMERON said he had a letter from a leading civil engineer informing him that an important British link of railway on the southern boundary of British Columbia would be completed in 1900; in fact, it was thoroughly understood that very shortly there would be British rail connection between Rossland and the Pacific.

The vote of thanks was then put, and carried unanimously.

Miscellaneous.

THE USES OF FLOUR IN CHINA.

Although rice is generally regarded by the Chinese as the staff of life, a large quantity of wheat has been used from the most ancient times, and in the earliest classifications, wheat is mentioned as one of the five grains. In the northern provinces, where rice is not grown, and can only be purchased by the well-to-do, wheat is the most common cereal, but it is of very poor quality. The wheat is ground by a very primitive process. The mill consists of two large stones which are turned by the aid of a blindfolded mule. The flour is coarse and dark, chiefly used in the form of vermicelli, and when steamed, makes a good substitute for rice, and when mixed with a little broth, flavoured with a dash of soy, it forms a very savoury dish. To use the Chinese term, they are the "suspended" and the "dropped;" the former is the true vermicelli, the manufacture of which is a common sight in many northern villages, where strings of the

paste, fastened at the ends of two light sticks, are suspended before the doors of the cottages even in the main streets. The chopped vermicelli is made by rolling out the dough and cutting it into thin strips with a knife fastened to the board like a straw chopper. The United States Consul-General at Shanghai says that wheat flour is also used for making rolls which are lightened with leaven, and these are cooked by steaming, as are the many varieties of patties containing minced meat, molasses, or a kind of jam. The steamer consists of sieves, fitting tightly one upon another, which are covered and placed over the kettle in which the meat or other food is being cooked. The ordinary Chinese, whether in city or village, takes his breakfast at the tea-house or restaurant. It consists almost entirely of these meat rolls or patties; the latter are dipped in vinegar, soy, or a solution of red pepper when eaten. Sometimes the steamed rolls, after they have grown old, are made palatable by being toasted on a grill over a charcoal fire. Another popular dish is dough nut fried in oil. Baking is almost entirely unknown, but there is a cake of the size and shape of an ox rib which is baked by being struck on the inside of a jar-shaped furnace on which there is a hot charcoal fire. These cakes are sometimes circular, but in every case they are covered with the seeds of the sesame which add very much to the flavour. Another variety is a large round cake cooked on a griddle, and which is divided into quarters when offered for sale. The Mohammedan Chinese make a similar cake, of which they are very fond, without using any pork fat. For the better quality of native pastry and confectionery, rice flour is used, but at the treaty ports and the cities to which foreign influence has extended many forms of sweet cake and biscuit are made of American flour.

COAL PRODUCTION IN THE ALPES MARITIMES.

The construction of the Sud de France Railways has opened up the question of the extraction for commercial purposes of the lignites, which exist to a large extent in the Nice Alps. Their existence has been known for many years; in 1831, the French geologist, de Villeneuve, considered they belonged to the cretaceous period, owing to an outcrop apparently conforming with a bed of gault. This opinion was also held as late as 1876 by Monsieur Camère, mining engineer, and author of a geological map of the district. Mr. Vice-Consul Jerome states that there are small beds of tertiary lignites in the immediate neighbourhood of Nice, but there is little doubt that the carboniferous beds, which are the object of the French Government concessions of Coursegoules, Carros, Le Broc, Tendon, &c., belong geologically to the same series as the Lettenkohle, or Kohlen-Keuper, of Würzburg, Tubingen, and Lorraine; like these they belong to trias, are below the lias, and above an oolitic formation, existing among beds known in France as *marnes irisées*, or *marnes*

bariolées, with gypsum. The analysis of the Lorrain Lettenkohle shows it to be of a very poor and impure nature, whereas in the Nice district, judging from the reports of the Government engineers, the lignites are of sufficiently good quality to enable them to be used for most purposes. Still this analysis shows them to be far inferior to the lignite of the Forest of Dean, but as Professor D. T. Ansted remarked in a lecture on coals and lignites in 1865, that even tertiary deposits a fair coal may exist, such as that of Zsil in Transylvania, the geological position may not always be a criterion by which one can judge of quality. There is one peculiarity in the bituminous deposits of the Nice Alps in which they differ from most lignites, that is to say the bed of coal seen continuous over an area of several square miles. The soundings made at Coursegoules, Vence, Carros, Le Broc, Tendon, Reveset, Seros, as well as on the other side of the Var to the north of Puget Théniers, show the deposits or strata to be of a more or less uniform nature, viz., two main seams of workable coal and lignite. In a report on the concession of Carros an engineer estimated that it would yield 1,100,000 tons of fuel. This concession is in close proximity to the Nice-Grasse line of the Sud France Railway and a branch line could be run into the mine itself should it ever be worked. It is not to be supposed that even if these mines are worked, that they would much affect the importation of English coals to Nice, unless sold at a very low price, and even then the lignite could never be used for gas-making purposes, but where they could, and probably would, be much used would be in connection with the cement-producing clays and marls of Saint Martin du Var, in which district the manufacture of plasters and cements is expected to attain considerable proportions.

Correspondence.

THE LIFE-WORK OF WILLIAM MORRIS

Though the matter is of such small importance to be scarcely worth discussing, yet inasmuch as Mr. Vincent Robinson charges me with making "inaccurate claims" on behalf of William Morris, "for work which he did not do," I feel bound, in self-defence, to say that having obtained a reference to the books Messrs. Morris and Company, I find that my memoir was not at fault in the matter, and that I made no "inaccurate claim." A carpet, to which the name "Peterhouse" was given, was supplied to the Rev. Dr. Porter, April 21, 1885.

I do not see why Mr. Robinson should feel aggrieved or slighted because I did not refer to the Peterhouse carpets. Even if I had heard of them, was surely no part of my business to refer to them in connection with someone else's work.

F. S. ELLIS.

Cockington, Torquay.

June 8, 1898.

Notes on Books.

CATALOGUE DES TABLEAUX DE MAÎTRES ANCIENS ET MODERNES des Ecoles Flamande, Française, Hollandaise, &c., et des Tapisseries, &c., composant le Musée formé à Anvers par M. Edouard Kums. Mai, 1898. 4to.

This is a handsomely printed catalogue of a well-known collection of paintings, fully illustrated with reproductions of the chief pictures. The collection, which consisted of 161 lots, was sold at Antwerp last month, and realised a total of over 1,300,000 francs. The first lot was a signed picture by Corot (*Le Matin*), which sold for 27,000 francs. No. 14, *Meissonnier, Le Fumeur Blanc*, which was not in good condition, fetched 20,000 francs; No. 15, *Millet, La Porteuse d'Eau*, 68,000 francs; No. 72, a portrait of Martin Pepyn by *Vandyck, 1632*, 60,000 francs. This picture was sold with the collection of William II., King of Holland, in 1850, for £358. No. 77, *Le Calvaire*, attributed to *Memling*, 30,000 francs; No. 82, portrait of *Theophraste Paracelse* by *Rubens*, 24,000 francs. This sold in the *Blenheim Palace* sale, in 1886, for 125 guineas, when it was stated to be the copy of a picture by *Mabuse*. No. 99, *Cuyp, Pâturage*, 28,000 francs. This was sold a few years ago by Mr. Martin Colnaghi for £60.

CATALOGUE D'UNE REMARQUABLE COLLECTION DE TABLEAUX ANCIENS provenant de M. J. G. David et d'un autre Amateur. Bruxelles, Mai, 1898. 4to.

A collection of 93 pictures by *Breughel, Honthorst, Jordaens, Weenix, Wouvermans, &c.* Among them were several English pictures, as a portrait of *Jonathan Shipley, Bishop of St. Asaph*, by *Mathew Brown*; portrait of a lady by *Cotes, &c.* The catalogue is illustrated by photographs of many of the pictures.

CLASSICS FOR THE MILLION. By Henry Grey, London. John Long, 1898. Small 8vo.

This small volume contains an epitome of the works of the principal Greek and Latin authors, beginning with *Homer* and ending with *Lucian* among the Greeks, and beginning with *Plautus* and ending with *Quintilian* among the Latin authors. In an Appendix, Mr. Grey gives the names of the principal English translators of each author.

SPONS' ARCHITECTS' AND BUILDERS' PRICE-BOOK, with useful Memoranda and Tables. By W. Young, Architect, London, 1898. Small 8vo.

It is not necessary to say much in praise of a book that has passed through twenty-five editions, as this fact alone is sufficient to prove that the book has been received with general favour. This handbook is divided into two parts, and the matter is arranged in each in alphabetical order. A chapter on electricity, with complete specifications and estimates of electric

lighting installations carried out by the author, has been added, and room has also been found for extra divisions on concrete, fireproof floors, and granite.

Obituary.

SIR ROBERT RAWLINSON, K.C.B.—The Society of Arts has lost an eminent and most active member in the person of Sir Robert Rawlinson, who died on Tuesday, 31st ult., at his residence, 11, The Boltons, South Kensington. Sir Robert was elected a member in 1855, and occupied a seat on the Council from 1872 to 1875, and again from 1877 to 1879. In 1880 he was elected a Vice-President, which office he again held from 1883 to 1885, and from 1888 to 1892. His first paper before the Society was read on February 3, 1858, the subject being "House Accommodation: its social bearing individually and nationally." The Earl of Shaftesbury was the chairman on this occasion, and he spoke in high terms of praise of Mr. Rawlinson, and of his own pleasure in having been associated with him for many years in works of improvement such as were described in the paper. In March, 1862, he read a paper on the "Sewering of Towns and Draining of Houses," and in 1877 he presented a paper to the Society's Domestic Economy Congress on "Buildings for Working Men." Sir Robert Rawlinson's most important communication was read in December, 1889, and was on "London Sewerage and Sewage," the discussion on this paper being adjourned to a subsequent meeting. In addition to these papers, he was a constant speaker at the meetings, especially when sanitary subjects were discussed, and he also frequently acted as chairman. He took an active part in the discussions at the Sanitary Conferences of the Society—Sewage, 1876, 1878; National Water Supply, 1878; Water Supply, Sewage, and Health, 1879; Water Supply, 1884.

Rawlinson was born at Bristol on February 28th, 1810, and at the age of 21 he entered the office of *Jesse Hartley*, engineer of the Liverpool docks, as a measurer of masonry. In 1836 he was in the service of *Robert Stephenson* as assistant resident engineer on the section of the London and North-Western main line at *Blisworth*. In 1840 he returned to Liverpool as assistant surveyor to the Corporation, and it was here that he turned his energies to sanitary engineering, to which subject he henceforth devoted his life with such signal success. He proposed in 1846 to supply Manchester and Liverpool with water brought by an aqueduct from *Bala Lake* in North Wales. It is, however, pointed out in *The Times* that he was not necessarily an advocate of other schemes of supply from the same source, as from his address to the Institution of Civil Engineers it appears that he was indisposed to exchange the Thames for a tract of Welsh moor as a source from which to provide London with water.

On the passing of the Public Health Act of 1848, Mr. Rawlinson was one of the first inspectors

appointed. One of the chief works of his life was undertaken when he was appointed in 1855, by Lord Palmerston's Government, one of three Commissioners to proceed to the Crimea to improve the condition of the soldiers. Not only were the Commissioners instructed to use the utmost expedition in examining into the causes of, and finding remedies for, the unhealthy state of camp and hospital, but they were ordered to see, either personally or through their agents, that works considered necessary were immediately begun, and to superintend their progress day by day until they were finished. The sending of Rawlinson to the Crimea, and the large powers given to the Commission, were largely owing to the lively interest which Lord Shaftesbury took in the improvement of the conditions in which the British army were placed. So great was the effect of the action of the Commission, that from about 42 per cent. in February, the death-rate fell to about $2\frac{1}{4}$ per cent. at the end of June. During this arduous time, Rawlinson was in constant communication with Miss Nightingale. The result of the labours of the Commission has been to permanently reduce the annual mortality of the British Army.

The next great work which Mr. Rawlinson undertook was at the time of the Cotton Famine in 1863, when he and Mr. Farnell were despatched to Lancashire to inquire into the feasibility of a proposal to start works of "utility, profit, and ornament," in order to provide employment at a fair wage for the starving workers. After visiting and inspecting ninety of the principal places, Mr. Rawlinson reported that, in his opinion, £1,500,000 sterling might be expended in permanent improvements of a beneficial character, such as main sewerage, drainage, forming and completing streets, making new water-reservoirs, and laying out parks and recreation-grounds. In consequence of this report, the Treasury authorised the advance out of the Consolidated Fund of a sum not exceeding £1,200,000, at $3\frac{1}{2}$ per cent. on the security of the local rates, to facilitate the execution of the public works suggested. The experiment succeeded, and Mr. Rawlinson computed that if all the streets and roads in Lancashire that were at this time sewered, drained, paved, and generally improved were added end to end they would form a roadway 400 miles long. In this undertaking £1,850,000 was spent. In recognition of his services Mr. Rawlinson was made a C.B. in 1865. On the constitution of the Local Government Board he became chief engineering inspector, and in retiring from the post in 1888 he was created a K.C.B., having been knighted six years previously. He acted as Chairman of the Royal Commission on the Pollution of Rivers in 1866, and served on the Commission which inquired into the sanitary condition of Dublin in 1879. In 1894 he was elected President of the Institution of Civil Engineers.

Sir Robert Rawlinson took much interest in art, especially in architecture. When he was assistant-surveyor to the Corporation of Liverpool he was

brought into contact with H. L. Elmes, architect of St. George's-hall, and he designed and constructed for that great hall the hollow brick ceiling which is said to be one of the lightest works of the kind in existence. He possessed a fine collection of pictures and water-colours, and was a collector of Chinese ivories, &c.

General Notes.

INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.—The Department of Science and Art has received through the Foreign-office information that the Third International Congress of Applied Chemistry will be held at Vienna from the 28th July to the 2nd August next.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JUNE 13...United Service Institution, Whitehall, S.W., 3 p.m. Captain Lushington, "A Reasonable System of Coast Defence."

TUESDAY, JUNE 14...London Chamber of Commerce (Incorporated), 10, Eastcheap, E.C., $2\frac{1}{2}$ p.m. Mr. W. F. Wenyon, "British Trade in South China (South of the Yangtze)."

Medical and Chirurgical, 20, Hanover-square, W., $8\frac{1}{2}$ p.m.

Colonial Inst., Whitehall-rooms, Whitehall-place, S.W., 8 p.m. Lord Brassey, "Recent Social and Political Progress in Victoria."

Asiatic, 22, Albemarle-street, W., 4 p.m.

WEDNESDAY, JUNE 15...Meteorological (in the Rooms of the Royal Astronomical Society, Burlington-house, W.), $4\frac{1}{2}$ p.m. 1. Mr. R. C. Mossman, "Frequency of Non-Instrumental Meteorological Phenomena in London with different Winds from 1763 to 1897." 2. Mr. A. Lawrence Rotch, "Progress of the Exploration of the Air by means of Kites at Bluehill Observatory, Mass., U.S.A."

Microscopical, 20, Hanover-square, W., $7\frac{1}{2}$ p.m.

1. Exhibition of Sponges, by Mr. B. W. Priest. 2. Mr. F. W. Millett, "Report on the Foraminifera of the Malay Archipelago" (continuation).

Patent Agents, 19, Southampton-buildings, W.C., 3 p.m. Annual General Meeting.

THURSDAY, JUNE 16...Royal, Burlington-house, W., $4\frac{1}{2}$ p.m. Antiquaries, Burlington-house, W., $8\frac{1}{2}$ p.m.

Linnean, Burlington-house, W., 8 p.m. 1. Mr. Miller Christy, "Observations on the Seasonal Variations of Elevation in a Branch of Horse Chestnut Tree." 2. Mr. G. H. Carpenter, "Pantopoda collected by Mr. W. S. Bruce in the neighbourhood of Franz Josef Land." 3. Mr. J. E. Duerden, "Morphological Relationships of the Actinaria and Madreporaria." 4. Dr. C. T. Forsyth Major, "Some Fossil Leporines."

Chemical, Burlington-house, W., 8 p.m. 1. Dr. G. T. Moody, "Preparation of a Standard Acid Solution by direct Absorption of Hydrogen Chloride." 2. Messrs. J. A. Gardner and G. B. Cockburn, (a) "Researches on the Terpenes. III.—Halogen Derivatives of Fenchene and their Reactions;" (b) "Researches on the Terpenes. IV.—The Oxidation of Fenchene."

Historical, 28, Jermyn-street, S.W., $8\frac{1}{2}$ p.m.

Numismatic, 22, Albemarle-street, W., 7 p.m.

FRIDAY, JUNE 17...Quekett Microscopical Club, 20, Hanover-square, W.C., 8 p.m.

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FRIDAY, JUNE 17, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One Hundred and Forty-fourth Annual General Meeting for the purpose of receiving the Council's Report and Treasurers' Statement of receipts, payments, and expenditure during the past year, and also for the election of officers and new members, will be held in accordance with the By-laws on Wednesday, 29th June, at 4 p.m.

(By order of the Council),

HENRY TRUEMAN WOOD,
Secretary.

CONVERSAZIONE.

The Society's *Conversazione* will take place at the Natural History Museum, Cromwell-road, S.W. (by permission of the Trustees of the British Museum), on Wednesday, 22nd June. The reception by Major-General Sir Owen Tudor Burne, G.C.I.E., K.C.S.I., Chairman, and the other members of the Council will commence at 9 p.m.

The following portions of the Museum will be open:—On the Ground Floor—the Central Hall, British Saloon, and Bird Gallery; on the First Floor—the East and West Corridors.

A selection of music will be performed by the Band of the Royal Marine Light Infantry in the Central Hall, and by the Red Hungarian Band in the Bird Gallery, commencing at 9 o'clock.

Each member is entitled to a card for himself (which will not be transferable), and a card for a lady. In addition to this, a limited number of tickets will be sold to members of the Society, or to persons introduced by a member, at the price of 5s. each, if purchased before

the date of the *Conversazione*. On that day the price will be raised to 7s. 6d.

These tickets will only be supplied to persons presenting members' vouchers (which can be obtained from the Secretary) or a letter of introduction from a member.

Members can purchase these additional tickets by personal application, or by letter addressed to the Secretary. In all cases of application by letter a remittance must be enclosed. Each ticket will admit one person, either lady or gentleman, and must be signed by the member applying for it.

Light refreshments (tea, coffee, ices, claret cup, &c.) will be supplied.

The entrance to the Museum is in the Cromwell-road. Carriages must enter the grounds by the east gate and leave by the west gate. The cards must be given up on entering the Museum.

Visitors arriving or leaving by either of the Metropolitan Railways will be allowed the use of the District Company's Subway, which leads from the South Kensington Railway Station direct into the grounds of the Museum.

Fuller particulars as to the musical and other arrangements will be given in the Programmes which will be distributed on the evening.

The cards of invitation have been issued to members.

MEDALS.

The Council have awarded the Society's Silver Medal to the following readers of papers during the Session 1897-98:—

To PROF. JAMES DOUGLAS, for his paper on the "Progress of Metallurgy and Metal Mining in America during the last Half Century."

To SAMUEL RIDEAL, D.Sc., for his paper on "The Purification of Sewage by Bacteria."

To CAPTAIN B. F. S. BADEN-POWELL, for his paper on "Kites: their Theory and Practice."

To PROF. J. A. EWING, F.R.S., for his paper on "Linde's Method of Producing Extreme Cold and Liquefying Air."

To PROF. SILVANUS P. THOMPSON, F.R.S., for his paper on "Telegraphy Across Space."

To MISS CLIVE-BAYLEY, for her paper on "The Revival of Hand-loom Weaving."

To J. K. STARLEY, for his paper on "The Evolution of the Cycle."

To HERBERT MILLS BIRDWOOD, C.S.I., M.A., LL.D., for his paper on "The Plague in Bombay."

To HENRY LUTTMAN-JOHNSON, I.C.S., for his paper on "The Earthquake in Assam."

To SIR ALFRED COMYNS LYALL, G.C.I.E., K.C.B., D.C.L., for his paper on "Chartered Companies and Colonisation."

To NEVILLE LUBBOCK, for his paper on "The West Indies and Sugar Bounties."

To J. HUNGERFORD POLLEN, for his paper on "Renaissance Woodwork in England."

To SIR E. MAUNDE THOMPSON, K.C.B., for his paper on "English Art in Illuminated MSS."

The thanks of the Council were also voted to the following members of the Council:—

To R. BRUDENELL CARTER, F.R.C.S., for his paper on "Children's Sight."

To CAPTAIN W. DE W. ABNEY, C.B., F.R.S., for his paper on "Photography and Colour Printing."

To LEWIS FOREMAN DAY, for his paper on "The Making of a Stained Glass Window."

CEYLON TEA-BOX WOODS.

BY FREDERICK LEWIS, F.L.S.,
Assistant Conservator of Forests, Ceylon.

The increasing export of tea from Ceylon, which must now be regarded as having more than fully taken the place of the island's former staple—coffee, has developed a correspondingly large trade in woods suitable for the manufacture of boxes for the packing and transport of the prepared article. Some notion of the volume of wood required yearly may be arrived at from the fact that, assuming all the tea exported from the island to be packed in 100 lb. chests, the total number of chests for one year's export alone would be over a million, or, roughly speaking, upwards of 18,000,000 superficial feet of planking.

Of this vast quantity, for some years past a great proportion of the wood has come from Japan, as both planters and merchants found by experience that the Japanese tea box was not only very neat, but it had the superior advantage over the locally made article, in possessing greater equality of weight. The importance of the last consideration cannot be too highly valued by the planter, as fluctuation of weight would in all cases lead to the contents of the box being emptied out and re-weighed, for obvious reasons; entailing not only additional cost and delay, but a serious loss by waste.

London importers also raised objections to certain Ceylon wood packages on the grounds of "tainted teas," implying thereby that the teas themselves had acquired a taint from the smell of the outer wood package, notwithstanding the fact that between the wood and

the tea itself is an air-tight envelope of lead. A still further objection was raised, that certain woods corroded the lead lining, and introduced poisonous matter.

It is, perhaps, foreign to the purpose of this paper to enter into any discussion as to the merits of the above objections, as, unfortunately, those most interested accept as final what is told them by their London constituents.

Now that the importation of tea-box wood has declined from Japan, owing to the late Chino-Japanese war, the demand in Ceylon for local woods for cases at once increased, and the demand for soft light woods rapidly began to manifest itself. The trade is practically in native hands, and for this reason the planter is often placed at a serious disadvantage, as he is absolutely ignorant of the extent of seasoning his packages have received, and very frequently is equally ignorant as to the materials themselves.

The trader is interested chiefly in obtaining woods that are light, and these he buys from people who have wood for sale; and so long as these will *float*, the log dealer will invariably find a ready sale for his produce, no matter if it is composed of all sorts, or of wood, green or dry. It will be further understood that the log dealer—for so he is—buys his wood wherever he can get it near navigable streams, and as these are very subject to periods of flood, as well as periods of non-navigability, it follows that he must often be for months unable to move his wood, during which time it has either stranded in the stream, or in the forest just as it was felled. Such conditions are not conducive to improved seasoning; and, naturally, wood exposed in this manner to tropical atmospheric changes cannot but suffer in turn. It is, moreover, remarkable that tropical soft woods are much more easily affected than woods imported from temperate zones. Finally, in Ceylon, the forests cannot be regarded as possessing any large extent of gregarious woods; in other words, pure forests do not exist, so that the log dealer can only adopt his standard of lightness as his rule for selection, and not that of species only. It is not to be wondered at, therefore, that our locally made tea boxes are mixed as regards their composition, and equally mixed as regards their specific weights.

That much could be done to remedy this state of affairs goes without saying, and it is to be deplored that so large an industry suffers from want of systematic arrangement, which would go far to reduce the evils complained of,

if not to absolutely eliminate it altogether. It is proposed to give a short list of local timbers in use in Ceylon, with their local names added, as in that country the native name is more generally applied than the scientific.

MAGNOLIACEÆ.

- No. 1. *Michelia nilagirica*, Zenk. "Flora Brit. India," vol. i., p. 44. Singalese—*Wal-Sapu*.

This is a purely hill species, and is rarely found below 4,000 feet altitude, and not over abundant. It is in demand owing to the neatness of package it affords and beauty of wood.

- No. 2. *Michelia Champaca*, L. "Flora Brit. India," vol. i., p. 42. Singalese—*Sapu*.

An introduced species, found chiefly in gardens, where it was probably introduced many years ago for the sake of its highly scented flowers which are used as offertories at Budhistic shrines. The wood is greatly prized, and only occasionally found in use for tea-boxes, for which it is far too good.

ANONACEÆ

- No. 3. *Cyathocalyx zeylanicus*, Champ. "Flora Brit. India," vol. i., p. 53. Singalese—*Ippatta*.

Fairly abundant plant, and found through most of the wet forests in the western and Sabaragamuwa provinces, from practically sea level to 2,000 feet. It is a favourite wood, as it grows very straight, and only branches high up, so that it is easily worked.

- No. 4. *Xylopia parvifolia*, Hook f. and Thoms. "Flora Brit. India," vol. i., p. 84. Singalese—*Netawu*.

Like the last, is a wet forest plant; common, but not particularly abundant. It is, perhaps, more common in the Gillimali country, at the base of Adam's Peak, than further to the east. It affords a nice, clean-looking wood, but is not in very high demand, as it is said to be too heavy.

GUTTIFERÆ.

- No. 5. *Calophyllum tomentosum*, Wight. "Flora Brit. India," vol. i., p. 274. Singalese—*Kina*.

A hill species, and a favourite wood for building purposes in general, and occasionally used for tea boxes, but unsuitable on account

of weight. A beautifully marked wood and very durable.

DIPTEROCARPACEÆ.

- No. 6. *Doona congestiflora*, Thw. "Flora Brit. India," vol. i., p. 312. Singalese—*Tiniya*.

A large tree, and found growing gregariously in many of the wet forests of the island. It affords a timber much like cedar in appearance, light, and easily worked, and, therefore, is in great demand.

- No. 7. *Vateria acuminata*, Hayne. "Flora Brit. India," vol. i., p. 313. Singalese—*Hal*.

A large handsome tree, widely distributed in the western, southern, and Sabaragamuwa provinces, but rarely found above 3,000 feet altitude or out of the very wet limits. The wood is in great demand as it is very easily worked, light, and lasting. This tree runs some risk of becoming destroyed altogether, as the natives strip off the bark from young and old trees, to assist in stopping fermentation in toddy, for which purpose it is freely used, to the destruction of the tree. The fruit is also eaten, so that the tree has many vital enemies to its existence.

MALVACEÆ.

- No. 8. *Bombax malabaricum*, DC. "Flora Brit. India," vol. i., p. 349. Singalese—*Katu-imbul*.

An enormous tree, scattered over the greater part of the west of Ceylon, up to 2,500 feet, above which it becomes very scarce. It is found in the dry districts towards the south, where it attains a stem circumference of 15 to 18 feet. Owing to its great lightness and the neatness of box turned out from the wild cotton tree, it is a great favourite and commands a good price. The natural reproduction of the tree is not good, so that in its wild state the tree stands some risk of being very much overworked.

- No. 9. *Cullenia excelsa*, Wight. "Flora Brit. India," vol. i., p. 350. Singalese—*Katu-boda*.

A common tree in all the wet forests up to 4,000 feet, and occasionally a gregarious plant. It has only of late years come into favour as a tea-chest wood, and bids fair to become popular, as the timber is light and easily worked, and rather pretty.

SIMARUBACEÆ.

- No. 10. *Ailantus malabarica*, DC. "Flora Brit. India," vol. i., p. 518. Singalese—*Wal-billin* or *Kumbalu*.

A large lofty tree, but found in no great abundance. It yields a very soft wood, and is easily worked. In parts of the Kegalla district the local carpenters pass off a good deal of this wood as wild cotton, so as to secure a sale for it, owing to the popularity of the latter species.

BURSERACEÆ.

- No. 11. *Canarium zeylanicum*, Bl. "Flora Brit. India," vol. i., p. 532. Singalese—*Kekuna*.

A very large forest tree, and found chiefly on rocky ground in the wet zone, up about 2,000 feet. Very common in suitable places in the western province, especially in the Pasdun Korah. The wood is very light, and easily worked, but is so soft that it decays very quickly. The bark contains a pungent, balsamic resin that is said by the natives to be a valuable specific against snakes, if burned in a house. The seeds are eaten, and in flavour are not unlike walnuts.

MELIACEÆ.

- No. 12. *Melia dubia*, Cav. "Flora Brit. India," vol. i., p. 545. Singalese—*Lunu-midella*.

A large and conspicuous tree, with crowded bipinnate leaves that form tuft-like terminations to the long thin branches. It is not a tree of very general distribution in Ceylon, as it seems to prefer certain soils, out of which it does not flourish. It is cultivated in the Kegalla district both by natives and Europeans, and, owing to its rapid growth, it is a favourite. The wood is in very great demand, both for its suitability for the making of outriggers for native boats and for ceiling boards, and also tea boxes. It is light in weight, easily worked, and durable. This wood has been tried for fuel purposes, but is not found to be a success as such.

The cultivation of *Lunn-midella* is profitable, as in eight years the tree attains sufficient size as to be saleable.

- No. 13. *Chickrassia tabularis*, A. Juss. "Flora Brit. India," vol. i., p. 568. Singalese—*Hulan-hick*.

A moderately large tree, but not common. It has been used a tea-box wood, but is not

adapted to this purpose, for which it is much too good, owing to its weight. It is a very ornamental wood, and suitable for carving.

- No. 14. *Cedrela serrata*, Royle. "Flora Brit. India," vol. i., p. 561.

This is an introduced timber tree, and is known as "Red Toon." Its introduction has been quite of recent years, and its success has been somewhat questionable, owing to the young plants being subject to the attacks of a "borer" that quite destroys the part attacked, and often the whole tree. The wood is a favourite for tea chests, and at one time was largely imported into Ceylon for this special purpose.

OLACINEÆ.

- No. 15. *Lasianthera apicalis*, Thw. "Flora Brit. India," vol. i., p. 584. Singalese—*Urukannu*.

A large handsome tree, the young leaves of which have a conspicuous coppery hue, and highly polished upper surface. It is abundant in parts of the western province, and ascends to a considerable altitude in the wet zone. The wood is not in great favour, chiefly because of its weight, but while it can be obtained easily, carpenters readily buy it for local use.

Trimen gives *Uruhouda*, *Uructa*, and *Kos-penua* as further native names, but it is more generally known by the name given above.

CELASTRACEÆ.

- No. 16. *Kokoona zeylanica*, Thw. "Flora Brit. India," vol. i., p. 616. Singalese—*Kokoon* or *Kokoon pottu*.

A very common tree in the very wet forests near the foot of Adam's Peak, and in the districts extending towards the west coast.

The wood is not very favourable, because of its splitting so freely, but is suitable for small cases.

ANACARDIACEÆ.

- No. 17. *Mangifera zeylanica*, Hook. f. "Flora Brit. India," vol. ii., p. 16. Singalese—*Walamba*, *Etamba* (*Amba*, lit. a kidney).

A large and handsome tree of wide distribution, extending from the confines of the dry country in the south-west, all over the wet forests up to 2,500 feet, after which it becomes scarce. The tree attains a very large size with a long clean stem. The wood is a pale white, soft, and easily worked, and is in large demand for cases.

- No. 18. *Semecarpus subpeltata*, Thw. "Flora Brit. India," vol. ii., p. 33. Singalese—*Maha-badulla*.

A moderately large straight tree, found in all the very wet forests of the Western Province and Sabaragamwa, particularly within the water-shed of the Kaluganga river.

This wood is in particular demand for tea chests, though it is said to be one of the woods that corrode tea with lead or the lining used between the tea and the wood.

- No. 19. *Semecarpus coriacea*, Thw. "Flora Brit. India," vol. ii., p. 32. Singalese—*Badulla*.

A common tree, found over most of the hill country above 4,000 feet. This wood is sometimes used, but it is considered too bad owing to the risk there is of getting any of the "milk" (Sing., *Badulla kiri*.) on the skin, as it at once sets up a violent inflammation. It is possible that two or more than those mentioned of this genus are used, as the Singalese name *Badulla* extends to both the large as well as small forms of *Semecarpus*, and the word coming within the "light" class would be accepted for the purpose intended.

- No. 20. *Camptosperma zeylanicum*, Thw. "Flora Brit. India," vol. ii., p. 41. Singalese—*Arridda*.

A large dark-leaved tree, and in many of the wet forests in the vicinity of Adam's Peak it is a gregarious species. In Gillimali—at the foot of Adam's Peak, eight miles from Ratuapura—these trees are found in great abundance, attaining a girth of seven feet. It is in very high favour for tea-chest manufacture, as it affords a light, easily-worked, clean-looking wood, possessing all the qualifications necessary to commend it to the planter.

RHIZOPHORACEÆ.

- No. 21. *Anisophyllea zeylanica*, Benth. "Flora Brit. India," vol. ii., p. 442. Singalese—*Wellipenna*.

A tree attaining considerable size, and found in moderate abundance in all the wet forests of the western half of the island, up to 2,500 feet, after which it becomes scarce.

It is occasionally used for tea boxes, but is not a favourite for that purpose, as it is too heavy.

DATISCAEÆ.

- No. 22. *Tetrameles nudiflora*, R. Br. "Flora Brit. India," vol. ii., p. 657. Singalese—*Mugunu*.

A very large tree, distributed mostly through the country having the intermediate rainfall between the wet and dry zones. The wood is very soft and light, and occasionally mixed up with harder kinds in the manufacture of chests.

CORNACEÆ.

- No. 23. *Mastixia tetrandra*? Clarke. "Flora Brit. India," vol. ii., p. 745. Singalese—*Diya-taliya*.

A large wet-zoned tree, and found in abundance in the valleys of the Kaluganga watershed. The wood is much sought after, and is suitable owing to lightness.

RUBIACEÆ.

- No. 24. *Sarcocephalus cordatus*, Miq. "Flora Brit. India," vol. iii., p. 22. Singalese—*Bakmi*.

A rather common tree in the wet ground, with exceedingly large stipules. The wood is light and soft, but not in great favour.

SAPOTACEÆ.

- No. 25. *Chrysophyllum Roxburghii*, G. Don. "Flora Brit. India," vol. iii., p. 535. Singalese—*Lāwulu*.

A moderately large tree, scattered sparingly over the wet zone, and occasionally used for tea-box manufacture, but not in great favour, as trees of sufficient size are difficult to procure.

- No. 26. *Palaquium grande*(?), Engler. "Flora Brit. India," vol. iii., p. 540. Singalese — *Mihiria*, *Kirihimbilia*, *Kirihiria*.

A very large, thick, brown-barked tree, of wide distribution in all the moist forests of the country, up to about 4,000 feet altitude. It is a favourite building wood on estates, and is often used for tea cases. The wood is reddish in colour, dark and close.

APOCYNACEÆ.

- No. 27. *Alstonia scholaris*, R. Br. "Flora Brit. India," vol. iii., p. 642. Singalese—*Rukattana*.

A very large, tall tree with pale grey stem and dark whorled leaves, found throughout the low country up to 3,000 feet, except in the dry

zones. This wood is much sought after owing to its extreme lightness, and is greatly in use for the manufacture of coffins. In colour the wood is white, and when freshly cut is offensive in smell.

MYRISTICACEÆ.

- No. 28. *Myristica laurifolia*, Hook. f. and Thoms. "Flora Brit. India," vol. v., p. 103. Singalese—*Malaboda*, *Rerimarwara*.

A very common tree in all the wet forests up to 5,000 feet, and frequently found on the banks of streams in the dry zone. The wood, if carefully seasoned, affords a splendid packing-case material, but the difficulty in drying the timber is against its popularity. It splits freely and is of a pale yellow colour.

- No. 29. *Myristica Horsfieldia*, Bl. "Flora Brit. India," vol. v., p. 106. Singalese—*Ruk*.

A large tree, fairly abundant in the moist zone, with particularly sweet-scented flowers. The wood very much resembles the last in appearance, but is much more heavy, and for this reason is rarely used in the manufacture of tea boxes.

- No. 30. *Myristica Irya*, Gaertn. "Flora Brit. India," vol. v., p. 109. Singalese—*Iriya*.

A common tree on the banks of rivers and streams, and often in swampy places. It has a bright pink pericarp, with seeds enclosed entirely by a scarlet aril.

The wood strongly resembles that of the last-named species, but is lighter and is in demand.

LAURACEÆ.

- No. 31. *Cryptocarya membranacea*, Thw. "Flora Brit. India," vol. v., p. 120. Singalese—*Tuwanna*. *Walkos*.

A wet zone tree, and abundant in the Gillimali district at the foot of Adam's Peak and towards the "Haycock," on the borders of the southern province. A yellowish coloured wood, close-grained, and well adapted to tea-box manufacture, but not particularly used owing to weight.

- No. 32. *Machilus glaucescens* (?) *zeylanica* (Trimen's Catalogue, *M. macrantha*, Trim. "Flora of Ceylon," vol. iii., p. 443), "Flora Brit. India," vol. v., p. 140. Singalese—*Ulalu*.

A very large tree found in some abundance

in the Arisawella district and towards Adam's Peak.

It is a favourite tea-box wood, as it is easily worked and of a light weight. Dry saw-dust of this wood is faintly aromatic in smell.

- No. 33. *Litsea sebifera*, Pers. "Flora Brit. India," vol. v., p. 157. *L. chinensis*, Trimen. "Flora of Ceylon," vol. iii., p. 449. Singalese—*Bomi*.

A common tree throughout the island up to 2,500 feet, and well known to all local carpenters. The wood is in great favour for flooring boards as it is capable of taking a superior polish. Frequently used in the tea-box trade.

- No. 34. *Litsea zeylanica*, Nees. "Flora Brit. India," vol. v., p. 178. Singalese—*Kududawula*.

A common tree in the hill country, between 2,000 and 4,000 feet, and in great favour not only for tea cases but for door frames, sash bars, dados, and the like. The wood is light in weight, and will take a high polish of a yellowish orange colour.

EUPHORBIACEÆ.

- No. 35. *Aleurites triloba*, Forst. Singalese—*Tel-kekuna*.

An introduced tree and common enough in native gardens, where it is cultivated for the sake of the oil that is extracted from the nut. Sometimes, but very rarely, used in tea-case manufacture. The wood is white, soft, and light.

URTICACEÆ.

- No. 36. *Ficus nervosa*, Hayne. "Flora Brit. India," vol. v., p. 512. Singalese—*Kalamadua*.

A large-leaved tree, and occasionally found in the forests of the wet zone. The wood is soft and light, but decays quickly.

It is probable that a few more species of the genus *Ficus* get mixed up with other light soft woods in tea-box manufacture, as they are easily procurable in common with so many of the woods mentioned above, but it is undesirable to record any doubtful examples. The list given includes most, if not all, of the recognised tea-box woods, and to which, but for the ignorance of the traders themselves, many more might be added.

The culture of woods for this special trade may in course of time be tried in Ceylon, as the wants of the planters make suitable wood more and more scarce; but it is noteworthy

that no invention has yet been brought out by which compressed wood could be used instead of the present very laboriously manufactured article.

MICA MINING IN THE DISTRICT OF NELLORE, INDIA.

BY ROBERT W. THOMPSON,
A.M.I.C.E., M.S.A.

Nellore is one of the maritime districts of the Madras Presidency. It is bounded on the north by the district of Kistna, on the south by the districts of Chingleput and North Arcot, on the east by the Bay of Bengal, and on the west by the district of Cuddapah, from which it is separated by the Eastern Ghâts—a range of hills from 2,000 to 3,000 feet in height, running roughly parallel to the coast from fifty to sixty miles inland. The length of the district is about 180 miles, and the area about 10,000 square miles. The Great Northern road from Madras to Calcutta passes through the district south to north, keeping at an average distance of ten miles from the sea. Various other roads branch east and west from this trunk to populous and important villages. The chief town is Nellore, on the Pennar river, 180 miles from Madras by the Great Northern road; the next in importance are Ongole, 182 miles from Madras, and Gudur, 85 miles from Madras, both of which are also on the Great Northern road. Vencataghiri and Calastry are also important places, both being in the south-west of the district. There is railway communication with Madras, but the route is circuitous, and a break of gauge occurs at a place called Rennigunta where passengers tranship from the Madras railway, broad gauge, to the South Indian Railway, narrow gauge, the journey taking over sixteen hours; but the new Bez Wade-Madras State Railway, which will probably be opened for traffic this year, will give direct broad-gauge communication between Madras and Nellore, the journey taking not more than six hours. The district is salubrious and populous, the population being approximately 200,000. There is not sufficient employment for the lower, or cooly, class of the people, so that labour is plentiful and cheap, a man's wages (reduced to English money) being from 3d. to 4d. a day, and a woman's or boy's from 2d. to 3d.—nothing more. The district is intersected by numerous streams having their origin in the Eastern Ghâts, and one river—the Pennar—

which, rising in the tableland of Mysore, flows through the district of Cuddapah (receiving there the waters of the Chitravutty, the Paupugni, and the Cheyair), and then through a rift in the Eastern Ghâts past the town of Nellore into the Bay of Bengal, after a course of 355 miles.

East of the Great Northern road, and for a few miles to the west of it, the country is generally low and flat and the soil alluvial, and rice is largely cultivated upon it; to the west of this the ground begins to rise and becomes undulating and rocky, and is only fit for the cultivation of dry grains in some parts, the rest being barren or covered with jungle. The geological formation of this portion may be described as being generally a bed of metamorphic rock on which is superimposed a layer of laterite, which is a soft argillaceous stone of a reddish-brown colour, and of aqueous formation. The metamorphic rocks are represented by gneiss, mica schist, hornblends schist, and quartzite; these, though forming the bed rock of this part of the district, very often crop out above the surface and stand exposed. Instances of igneous rock are also met with in trap, felspar, and granite, the former occurring in dykes, and the two latter as isolated intrusions through the bed of metamorphic rock. This is the general aspect of the district: but laterite is occasionally met with in places nearer to the sea than above indicated, and alluvial land farther inland; this is naturally the case along the valleys through which streams flow.

Mica exists in the western parts of the district where the land begins to rise to the ghâts. The surface indication of it is the outcrop of quartz and felspar, with which minerals it is usually associated, being sometimes integrated with them so as to form a coarse-grained granite, or else occurring in large separate masses. It is not unusual to find distinct masses of mica, of quartz, and of felspar, lying contiguous to each other; the idea which they convey being that Nature intended manufacturing granite on the spot, but after collecting the necessary materials had changed her mind about it. But the surface indication, above mentioned, is not always present: in some cases mica occurs in isolated blocks. There are mica mines in operation at Inikurti, Utukur, Chaganum, Sydapuram, and Khandali, all lying from W.S.W. to S.S.W. of the town of Nellore, at from twenty to thirty miles distance. Indications of mica are met with further north, but no mines have yet

been started; the industry is in fact in its infancy, the first mine, the one at Utukur, having only been started in 1888. The mineral is found near the surface, and those hitherto engaged upon the getting of it not being professional miners, but mere diggers, the only method of working yet adopted has been that of quarrying—no subterraneous mining has yet been attempted. The mica occurs in masses of from 100 to 200 cubic feet; these masses have been found from near the surface to a depth of 70 feet, the method employed for detaching the stuff being blasting with gunpowder or dynamite.

The cutting and sorting of the mica after it is won from the quarry is a very important part of the industry: the value depends not only on the sizes of the sheets, but also upon their freedom from flaws and their clearness and transparency. Slabs of clear mica have been obtained of a superficial area exceeding two square feet; such pieces are however rare. But pieces of no more than four square inches find a ready market. All clear mica is cut into rectangular pieces of certain sizes. The clippings, or waste, have hitherto been thrown aside as useless; but inquiries have recently been made for this waste also, as the mineral is said to be useful as a lubricant when powdered. Some of the mines recently started have had their whole output bespoken by firms in Madras. New uses are continually being found for the mineral. A patent has recently been taken out in India for a composition, in which it is the principal ingredient, for the covering of boilers, steam-pipes, and the like, as it is a capital non-conductor of heat. A cartridge has also been recently invented in which, instead of paper or metal for the wrapping, mica is used, the advantages of the material for this purpose being manifold.

It is not easy to ascertain the actual cost of getting the material, the mine owners being naturally reticent on the subject; and, in fact, the cost must vary in different mines according to the quantity and quality of the mica obtained, and the depth at which it is found. That it is a very paying industry is clear from the eagerness with which both Europeans and natives are taking up land for mining.

From statistics obtained from the Sea Customs Department, it appears that during the first half of the year 1895 the quantity of mica exported from the port of Madras was 66,815 lbs., which increased to 71,030 lbs. in the second half, and to 89,330 lbs. in the first half of 1896. During last year (1896) no less

than 30 mining leases were taken out for 61 acres of land, for a total assessment of 3,192 rupees. The industry has hitherto been worked by men of small means, who have each taken up from one to two acres of land to operate upon. But recently some firms in Madras have been applying for large blocks of land for the purpose. In consequence of these applications Government have been reconsidering the question of their attitude towards the industry. Hitherto the rule has been a charge of a rupee an acre for the right of prospecting, and an annual rent of 50 rupees an acre for land taken up on lease for mining upon. But the term "prospecting" has not been clearly defined, nor have any maximum or minimum limits been laid down as to the sizes of blocks which may be taken up or the distances which must separate rival blocks. In consequence of this difficulties have arisen at times. Government have hitherto taken no interest in the outturn of the mines or the status of the lessees; they are inclined now to take an interest in both; they desire to encourage firms or companies to take up large blocks of land, say of about half a square mile in area, and while reducing the ground-rent to charge a royalty of 5 per cent. *ad valorem* on the outturn. The idea is that such firms or companies, by introducing improved methods of mining, would get better results than have yet been achieved and so earn a higher profit, in which profit Government desire to participate. The difficulty of accurately valuing the mica obtained is to be gotten over by ultimately accepting a broker's certificate as to what it realised on sale in London, or wherever it was disposed of; Government in the first instance exacting a royalty calculated upon the highest price it is likely to realise. A deposit of 500 rupees is to be made with each application for a lease of land or a license to prospect. The new rules have not yet been promulgated, but it is believed that the above is a pretty accurate forecast of what is coming. These rules will, of course, apply only to mining on Government land. Where it is desired to mine on land belonging to private parties, an arrangement must be come to with the owners. The Rajah of Vencataghiri owns much mica-bearing land in the district; his rates, at present, are a rupee an acre for prospecting, and an annual rent of 50 rupees an acre for mining.

It must not be supposed that all who have gone in for mica mining have been successful; there have been failures as well as successes;

but the successes have so far outnumbered the failures that, as has already been said, there is a considerable boom in the industry just now—as booms in India go. The failures have generally been due to ignorance; men have started mining where there was no mica. In some cases failures have been due to want of capital and spirit. One of the most successful mines in the district was abandoned by the original owner as unprofitable.

Besides mica, the district contains iron, copper, gypsum, kaolin, and garnets. The iron ore is of good quality and is worked by the natives to a small extent for supplying local wants. The copper ore was worked formerly, but the ore procurable near the surface being exhausted, the industry has been abandoned. It is not known to what extent these minerals exist. Gypsum, kaolin, and garnets are found, but are not worked. The kaolin, which is disintegrated felspar, is white, and appears to be of good quality. The garnets hitherto found have been poor.

ARTIFICIAL MINERAL WATERS.

With reference to a remark by Dr. Schunk in his presidential address before the annual meeting of the Society of Chemical Industry last year, that “to Dr. William Henry is sometimes given the credit of the invention of aerated waters,” Mr. William Kirkby has communicated to the *Pharmaceutical Journal* an article in which a claim is made for Thomas Henry. He writes:—I am not aware that Dr. William Henry, son of Thomas Henry, “has been credited with the invention of artificially aerated water as a beverage.” It is, however, on record that Thomas Henry, the father, was the inventor of artificial mineral waters, as appears from the following extract from Dr. Angus Smith’s “A Century of Science in Manchester” (1883, p. 127):—

“Whilst without going deeply into the history of artificial mineral waters and aerated drinks, we are inclined to believe that the elder Henry [Thomas Henry—born Oct. 26 (old style), 1734; his son William Henry—born 1774] was the true inventor, or evidently considered that he was the first in the field. Dr. Henry separated from his partner Mr. Thompson, taking for himself the magnesia and leaving the aerated waters to the latter.”

In order to ascertain to what extent we are really indebted to Thomas Henry in this matter, it may be well to briefly review his work in connection therewith.

The interest which he took in the questions dealing with fixed air (carbonic acid gas) and the impregnation of water with it, must have been very great if we may judge from the pertinent notes appended to the text

of his translation of Lavoisier’s “Physical and Chemical Essays.” That he edited and translated this work, which treated so fully of the history of carbonic acid gas and the endeavours to make artificial mineral waters, and in so doing exhibited such a thorough acquaintance with the whole of the subject, quite precludes the idea that he ever claimed to be the inventor of aerated waters. He was quite familiar with the work of Venel, Priestley, and others. Concerning the first of these, who was professor of chemistry in the University of Montpellier, he has a foot-note in which he claims for Dr. Brownrigg the honour of being the first to establish the identity of the gas in natural mineral waters with Boyle’s “factitious air” and choke damp.

In 1767 and 1768 Priestley was experimenting upon the artificial impregnation of water with fixed air, and in 1772 he returned to the subject in the hope of being able to devise a drink which should be a prophylactic against the scurvy in seamen. Priestley’s apparatus was simplicity itself, and was very soon improved upon by Nooth, Parker, and Magellan (Mag’alhaens). It was with a view to improving upon the glass machines in use that Henry designed the apparatus described in a pamphlet entitled: “Account of a method of preserving Water at Sea from Putrefaction and of restoring to the water its original pleasantness and purity, to which is added a mode of impregnating water in large quantities with fixed air for medicinal uses, on Board Ships, and in Hospitals, and likewise a process for the preparation of Artificial Yeast, by Thomas Henry, F.R.S., and member of the Medical Society of London. Warrington. Printed by W. Eyres for J. Johnson, No. 72, St. Paul’s Churchyard, London. MDCCLXXXI.” The portion dealing with the impregnation of water with fixed air affords indubitable proof that Henry only claimed for his apparatus that it made it possible to prepare aerated water on a larger scale than heretofore.

“*The Method of Impregnating Water in Large Quantities with Fixed Air, so as to give it the Properties of Mineral Water for the Use of the Sick on Board of Ships and in Hospitals.*”

“Dr. Priestley some years ago communicated to the Lords of the Admiralty a method of impregnating water with fixed air obtained from an effervescing mixture of chalk and vitriolic acid, and of making an artificial Pyrmont water. This operation has since been considerably facilitated by the invention of Dr. Nooth’s glass machine, with Mr. Parker’s and Mr. Magellan’s improvements. That machine, though admirably contrived for the preparation of such quantities of artificial mineral water as may be necessary in private families, would be too small for the sickly crew of a large ship. But it appears to me that a mode may be adopted by which the process may be performed on a much larger scale.

“The advantages which would proceed from an easily practicable method of supplying the sick men

in long voyages with such water must be obvious to every medical practitioner. The mineral waters of Pyrmont and Seltzer may, by these means, be closely imitated, and the artificial water will be beneficial in all cases in which the natural is found useful. By this process also may Mr. Bewley's mephitic julep be prepared—than which the *materia medica*, perhaps, does not afford a more efficacious or more grateful medicine in putrid fevers, scurvy, dysentery, bilious vomitings, hectic, &c."

It is interesting to notice Henry's use of the bladder as a primitive kind of pump. The first suggestion, however, for the use of mechanical means for increasing the pressure of the gas seems to have come from Priestley, who wrote, "I do not doubt . . . but that by the help of a condensing engine, water might be much more highly impregnated with the virtues of the Pyrmont Spring, and it would not be difficult to contrive a method of doing it.*

In 1785 Thomas Henry communicated to the Manchester Literary and Philosophical Society a paper by Haygarth upon the impregnation of liquids with fixed air, in which is described an ingenious apparatus, the essential feature consisting of a pair of household fire-bellows for increasing the pressure of the gas.

Beyond Dr. Angus Smith's reference to Henry's association with the commercial manufacture of mineral water I have not met with any written or printed record. Early in this century there was a Thompson engaged in this trade, and the firm is in existence to-day under another name, but when and for how long the partnership between Henry and Thompson existed, when it was terminated, and where the waters were made I have not succeeded in ascertaining. Mr. Ogden (Messrs. T. and W. Henry) informs me that the present building in which the celebrated magnesia is made was erected in 1810, and there are no vestiges of mineral water manufacture about the premises, neither do the business archives contain any records of transactions in goods of this class.

Thomas Henry's interest in fixed air extended beyond artificial mineral waters. In the pamphlet already referred to he describes a yeast made by impregnating with fixed air a mixture of flour and water thickened by boiling, and then mixing it with flour and warm water, and "setting to rise" before baking. He thus anticipated the production of aerated bread by about half a century. In 1785 he described a process for the aëration of beers and wines which had become rapid. The apparatus consisted of the lower globe of Nouth's machine with the neck closed by a perforated stopper; this was charged with chalk, water, and the necessary acid, and lowered into the cask containing the beer; the pressure of generated gas overcame that of the superincumbent liquid by which it absorbed until the point of saturation was reached.

It is clear, I think, that it is to Thomas Henry, apothecary and chemist, of King-street, Manchester,

and not to his son William, that the credit is due of being a pioneer in the manufacture of artificially aerated waters. It is worth noting that Henry's pamphlet was published in 1781, that is eight years before the establishment of the Geneva factory, and about twenty years before the establishment of English houses for the regular supply of these waters.

CIDER MAKING IN FRANCE.

With the decline of the grape crop in France, increased attention has been paid to the cultivation of apples and the production of cider. It may be well to state, before describing the several processes of cider making, that the quality of the cider will depend to a great extent upon the proper fermentation of the must or crude juice of the apple. So fully is this recognised that it has given rise to the French proverb, "No good cider without good fermentation and good ferments." Several days after the must is placed in barrels, a sort of ebullition is produced in the mass, bubbles of carbonic acid are disengaged, foam or froth rises to the surface, and the lees or dregs of the juice settle to the bottom; finally, the must loses its sweet taste, the sugar which it contained being converted into alcohol. This disturbance or transformation is produced by microbes, which, seen under the microscope, have the appearance of small cells. These are the ferments. There are different kinds of ferments, as there are different kinds of apples. One will produce a sweet cider, another a dry or "sharp" cider; one produces a fragrant, limpid drink, another gives a flat and turbid cider. There is, according to the United States Consul at Havre, still another kind of ferment, consisting of an aggregation of microbes commonly known as "mother of vinegar," which when introduced into cider transforms it into vinegar. In selecting the apples care should be taken that the must or expressed juice should contain all the elements necessary for the development of the ferments, namely albuminoid substances, mineral substances, &c. To be complete it should contain some tannin and a certain degree of acidity. In a word, to make good cider it is above all necessary to have the proper kind of apples. To sum up the qualities needed to produce good cider it may be stated that the fruit should be ripe and fragrant, averaging from two to four per thousand of acidity, containing with some mucilage a notable quantity of tannin (3 or 4 per cent.) and a large proportion of saccharine matter, say 15 per cent. In gathering the fruit care is taken to protect the apples against mud or other extraneous substances, which if introduced into the must retards fermentation and impairs the quality of the cider. All rotten apples are rigidly excluded, as it is contended that a few rotten apples will affect the flavour of the cider. The fruit being carefully selected the next step is to thoroughly crush it. In France a great variety of

* "Experiments and Observations on Different Kinds of Air," by Joseph Priestley, LL.D., F.R.S. 1790. Vol. I.

apple mills are used, but the best known are the systems of Simon, Savary, Mobille, Garnier, and Chapellier. After crushing the apples the usual practice is to place the pulp in uncovered vats or tubs, and leave it twelve or fourteen hours before pressing, stirring it meanwhile from time to time with wooden shovels in order to bring the mass into contact with the air. The principal advantage claimed to be derived from the maceration and aëration is that it improves the colour of the cider and makes it richer in tannic acid; but recently it has been found that these advantages can be attained as readily by aërating the must, or crude juice, and it is now the practice at the large cider factories to press the fruit as soon as it has been mashed. Vats or tubs are only had recourse to when water is added to the pressed mass for a second pressing. The modern cider press consists of a circular cage with a bottom on which the pulp or mashed apples are placed and then pressed by means of a screw—at first slowly, then progressively until the operation is completed. When the pulp has been thus drained, it is taken out and placed in vats or tubs, where it is macerated with a certain quantity of water, say two or three gallons of pure soft water to 100 lbs. of pulp, for twenty-four hours, after which it is subjected to a second pressure. In this way, from every hundredweight of pulp, several gallons more of cider are obtained. The expressed juice of the fruit, known as the must, having been placed in barrels, the next step is to obtain proper fermentation, the most delicate and troublesome process in the making of cider, and at the same time the most important, since upon it depends the quality of the product. The fermentation of cider differs essentially from that of wine. In the case of wine, all the sugar ought to be completely transformed into alcohol by the ferments or fermentative microbes, which play such an important part in this process. For cider, on the contrary, it is necessary that fermentation be promptly established, and last only a short time, in order that the must may be clarified before the sugar has been entirely transformed into alcohol. The sugar which remains after the first active fermentation will still maintain a slow fermentation in the cider which prevents it from becoming too acid and being transformed into vinegar. There are three conditions which largely influence fermentation, viz., temperature, aëration, and the acidity of the crude juice. Temperature plays an important rôle in the process of fermentation. At 32° Fahrenheit fermentative germs cease to multiply and become inactive; at a temperature of 130° to 140° many of them die. It is between 68° and 78° that they are most active. If therefore the temperature is too low it will be necessary to warm the must in order to accelerate fermentation. This is done by heating a small quantity of the fluid to about 135° or 140° Fahrenheit and then pouring it into the barrel. In France a specially constructed warming apparatus (*chauffe-cure*) is used for this purpose. As regards aëration, oxygen is an essential element in the process of fermentation, and it is

therefore necessary that the must be thoroughly aërated. The liquid is stirred from time to time, and a quantity drawn off now and then and returned to the barrel; the bung-hole is left open or stopped with a little cotton wool which admits the air, and at the same time excludes any injurious microbes that might find their way into the barrel. In spite of all precautions it sometimes happens that fermentation is retarded. This is the case when too many sour apples have been used, the result being an acid must. Some persons neutralise the acidity by throwing a handful of wood ashes into the liquid, and then agitating it; but the best makers think this manner of treating the must is apt to produce a flat cider without colour, and is therefore not to be recommended. They say it is better to avoid an excess of acidity by a proper choice of fruit. One means of increasing fermentation, much used by the French cider makers, is to add a small quantity of must made from the best apples, to the indifferent must, which acts as a leaven to produce fermentation. The ferments of good fruit, thus added, set immediately to work and multiply the fermentation germs so rapidly, that the deficiency in the must, to which it has been added, is soon overcome, and a fresh and complete fermentation takes place. In like manner, a good cider may be destroyed by the addition of a bad ferment, often unwittingly added, by not taking care to thoroughly clean the instruments and vessels employed in the fabrication of the cider. In France, an artificial leaven, made from apples of the best growth, is an article of commerce, and is much used to correct deficiencies in must of a poor quality. A quart of this leaven, costing about 4s., will serve to improve from 130 to 140 gallons of an indifferent must. This leaven, or artificial ferment, has been used with very satisfactory results for several years, and is apparently growing in favour with the large cider makers. After ten or fifteen days, fermentation ceases, a densimeter introduced into the cider shows its specific gravity to be from 10.15 to 10.20; the liquor has become clear, the grosser lees settling to the bottom and the lighter rising to the surface, so that the cider is, as it were, between two layers of lees. This is the time to draw it off. The cider having been drawn off into a clean barrel undergoes, after a certain time, a second fermentation, very much less energetic than the first. When this second fermentation becomes feeble and carbonic acid is no longer disengaged, the barrel is completely closed until the time arrives for using the cider when it is again drawn off by a spigot or faucet. Cider is preserved well enough in barrels when completely full, but when the barrel has been partly emptied there is danger of its degenerating in quality. This is so well understood in France that when a certain quantity of the cider has been drawn off, the remainder is protected by what is known as "Noel's protector," much the same as a simple covering or thin layer of oil, which excludes the air and prevents the entrance of noxious microbes which would soon transform the

cider into vinegar. Bottling cider has become a large industry in France. Good cider in bottles ought to be clear and sparkling, and when properly prepared is a popular table drink, not only on account of its pleasant and refreshing taste, but for the more important reason that cider is now regarded in France as the most hygienic of all drinks, much more indeed than the best of wines.

AMERICAN RAILS.

The production of rails of all kinds in the United States last year was 1,647,892 tons, an increase of 46 per cent. over 1896. The highest production ever reached was in 1887, when 2,139,640 gross tons were made, and the next largest production was in 1890, with 1,885,307 tons. The rail production of 1897 was composed of 1,614,399 tons of Bessemer steel rails rolled by the producers of domestic ingots; 30,121 tons of Bessemer steel rails rolled from the old steel rails and rolled from purchased blooms; 500 tons of open-hearth steel rails, and 2,872 tons of iron rails. The total production of Bessemer steel rails in 1897 amounted to 1,644,520 gross tons, against 1,116,958 tons in 1896.

It appears from the last number of the Melbourne *Journal of Commerce* that some excitement has been created in Victoria by the announcement that the Government has accepted an American tender for the supply of 80 and 100 lb. rails and fishplates required by the Railway Department. There were five tenders in all, consisting of two American, two British, and one German; the latter and one of the first named were informal. The quantity specified was 12,789 tons of steel rails and 1,250 tons of fishplates, and the lump sums of three tenders were: British, No. 1, £81,256, No. 2, £79,274; and American £75,471, delivered at Melbourne. The successful tenderer was the Pennsylvania and Maryland Steel Company of the United States, the relative prices being £4 19s. 9d. per ton for the rails, and about £9 7s. 8d. per ton for the fishplates, delivered at Melbourne, 3,505 to be delivered in six months, 3,510 tons in nine, and the balance in twelve months from signing of contract.

General Notes.

ALBANY COLLEGE OF FORESTRY.—A conference has been held at Albany to decide upon the location of 30,000 acres of land to be purchased by the State for the establishment of a college of forestry under the authorisation of an Act of the last legislature. Dr. Fernow, director of the new State College of Forestry at Cornell University, who was formerly

chief of the Forestry Division of the Department of Agriculture at Washington, formulated the conditions which the Cornell authorities had decided necessary for land for the purpose of the new college, and a canvass was made of the available property in the Adirondack woods which is on the market. This developed that there were not more than three or four tracts available, which it is believed the State could readily secure. These tracts are in Hamilton and Franklin counties, and it is held that they could be purchased at less than six dollars an acre. No particular plot of ground has been decided upon as yet.—*Scientific American*.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, JUNE 20...Chemical Industry (London Section), Burlington-house, W., 8 p.m. Dr. Hans Goldschmidt and Mr. Claude Vautin, "Aluminium as a Heating and Reducing Agent (in the production of Chromium and other Metals)."

Geographical, University of London, Burlington-gardens, W., 8½ p.m. Colonel Sir T. Hungerford Holdich, "Tirah: the Geographical Results of the Recent Afridi Campaign."

British Architects, 9, Conduit-street, W., 8 p.m. Presentation of Royal Gold Medal, and Address by the President.

TUESDAY, JUNE 21...Statistical (in the Theatre of the United Service Institution), Whitehall, S.W., 5 p.m. Mr. T. A. Coghlan, "Deaths in Child-Birth."

Photographic, 12, Hanover-square, W., 8 p.m. Captain W. de W. Abney, "Photographic Images."

Zoological, 3, Hanover-square, W., 8½ p.m. 1. Mr. J. Graham Kerr, "Remarks upon Series of Specimens of Lepidosiren and other Fishes obtained in Paraguay." 2. Mr. G. A. Boulenger, "Report on the Collection of Fishes made by Mr. J. E. S. Moore in Lake Tanganyika during his Expedition 1895-96, with an Appendix by Mr. J. E. S. Moore." 3. Mr. R. I. Pocock, "The Scorpions, Spiders, and *Solpugæ* collected by Mr. C. Stuart Betton in East Africa, between Mombasa and Uganda."

WEDNESDAY, JUNE 22...SOCIETY OF ARTS. Conversation at the Natural History Museum, South Kensington, 9 p.m.

Mining and Metallurgy, Geological Museum, Jermyn-Street, S.W., 8 p.m. 1. Mr. Edgar A. Ashcroft, "The Treatment of Broken Hill Complex Sulphide Ores by Wet Extraction Processes and the Electrolytic Deposition of Zinc." 2. Mr. A. F. Crosse, "Notes on the Payable Conglomerate Beds encased in Sandstone, and the Mining Methods in use for their Extraction on the Witwatersrand." 3. Mr. George Atwood, "The Density of Gold and Silver Alloys."

FRIDAY, JUNE 24...Aeronautical Society (at the House of the Society of Arts), 4½ p.m. Mr. G. L. O. Davidson, "The Flying Machine of the Future."

Physical, Chemical Society's Rooms, Burlington-house, W., 5 p.m. 1. Prof. Carus-Wilson, "Exhibition of an Apparatus illustrating the action of two coupled Electric Motors." 2. Mr. J. Quick, "Exhibition of Weedon's Expansion of Solids Apparatus." 3. Dr. F. G. Donnan, "The Theory of the Hall Effect in a Binary Electrolyte."

Journal of the Society of Arts.

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FRIDAY, JUNE 24, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.

FINANCIAL STATEMENT.

The following statement is published in this week's *Journal*, in accordance with Sec. 40 of the Society's By-laws:—

TREASURERS' STATEMENT OF RECEIPTS AND EXPENDITURE FOR THE
YEAR ENDING MAY 31ST, 1898.

[illegible]

	£	s.	d.	£	s.	d.
By House:—						
Rent, Rates, and Taxes	787	12	0			
Insurance, Gas, Coal, House expenses and charges inci- dental to meetings	256	18	9			
Repairs and Alterations.....	112	13	0			
				1,157	3	9
„ Office:—						
Salaries and wages	2,131	8	9			
Stationery, Office Printing and Lithography	298	4	0			
Advertising	88	19	0			
Postage Stamps, Messengers' Fares, and Parcels	222	1	7			
				2,740	13	4
„ Library, Bookbinding, &c.....				54	16	8
„ Conversazione (1897).....				456	18	3
„ <i>Journal</i> , including Printing and Publishing..	2,162	6	4			
„ Advertisements (Agents and Printing)	298	7	10			
„ Examinations	1,191	5	10			
„ Medals:—						
Albert	24	16	6			
Society's	23	6	0			
				48	2	6
„ Bookbinding Exhibition				19	4	8
„ “Stock” Prize				20	0	0
„ “Shaw” Prize				20	6	6
„ “Owen Jones” Prizes				22	1	0
„ Drawing Society's Prizes.....				11	2	0
„ “Cantor” Lectures				233	11	8
„ Juvenile Lectures				23	10	0
„ “Howard” Lectures				10	16	2
„ Sections:—						
Applied Art.....	62	12	0			
Foreign and Colonial	50	16	0			
Indian	78	5	4			
				191	13	4
„ International Congress on Technical Edu- cation.....				502	14	2
„ Committee on Deterioration of Paper				47	2	8
„ Committees (General Expenses)				8	3	0
				9,310	0	5
„ Cash in hands of Messrs. Coutts and Co., May 31st, 1898	1,495	16	1			
Do. in hands of Secretary.....	28	2	3			
				1,523	18	4
				£10,833	18	0

LIABILITIES.

	£	s.	d.	£	s.	d.
To Accounts due	290	7	8			
„ Examiners' Fees	542	6	0			
„ Examination Prizes and Medals	93	0	0			
„ Sections :—Applied Art, Foreign and Colonial and Indian	170	0	0			
„ Accumulation under Trusts	440	6	6			
				1,536	0	2
„ Excess of assets over liabilities				20,833	19	8

£22,369 19 10

ASSETS.

	£	s.	d.	£	s.	d.	
By Society's Funds invested as follows, and worth on 31st May, 1898:—							
£1,542 12s. Consols	1,723	17	1				
£500 Canada 4 per Cent. Stock	510	0	0				
£500 South Australia 4 per Cent. Stock	517	10	0				
£530 10s. 1d. New South Wales 3½ per Cent. Stock	572	18	10				
£500 New South Wales 4 per Cent. Stock	595	0	0				
£217 Great Indian Peninsula Railway 4 per Cent. Debenture Stock	359	2	8				
£1,500 Queensland 4 per Cent. Bonds	1,500	0	0				
£500 Natal 4 per Cent. Stock ...	505	0	0				
Ground Rents (amount invested)	10,490	2	9				
New River Company Share (New).....	432	10	0				
				17,452	1	4	
„ Subscriptions of the year uncollected	466	4	0				
„ Arrears, estimates as recoverable	170	0	0				
					636	4	0
„ Property of the Society (Books, Pictures, &c.)					2,000	0	0
„ Advertisements on the Books, due, and in course of execution					357	16	2
„ Cash in hands of Messrs. Coutts and Co., 31st May, 1898.					1,495	16	1
„ Do. on Deposit (interest on Trusts)					400	0	0
„ Do. in hands of Secretary					28	2	3
					£22,360	19	10

INVESTMENTS &c., STANDING IN THE NAME OF THE SOCIETY (INCLUDING TRUSTS AS BELOW).

Ground Rents (amount of cash invested)	£17,669	4	0
Consols	3,146	12	3
Metropolitan Railway 4 per Cent. Perpetual Preference Stock	500	0	0
Bombay and Baroda Railway 5 per Cent. Guaranteed Stock	2,450	0	0
Canada 4 per Cent. Stock	923	0	0
South Australia 4 per Cent. Stock	605	16	0
New South Wales 3½ per Cent. Stock	530	10	1
New South Wales 4 per Cent. Stock	500	0	0
Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock	2,170	0	0
Queensland 4 per Cent. Bonds	1,500	0	0
Natal 4 per Cent. Stock	500	0	0
New River Company Share (New)	100	0	0
Cash on Deposit with Messrs. Coutts and Co.	400	0	0

TRUST FUNDS INCLUDED IN THE ABOVE.

1. Dr. Swiney's Bequest	£4,500	0	0	Invested in Ground-rents (costing £4,477 10 0), and chargeable with a sum of £200 once in five years.
2. " John Stock Trust "	100	0	0	Consols, chargeable with the Award of a Medal.
3. " Benjamin Shaw " Trust for Industrial Hygiene	133	6	8	„ „ „ of Interest as a Money Prize.
4. North London Exhibition Trust	102	2	1	„ „ „ of a Medal. „
5. " Fothergill " Trust	388	1	4	„ „ „
6. J. Murray, in aid of a Building Fund	54	18	0	„
7. Subscriptions to an Endowment Fund	502	2	2	„
8. Dr. Aldred's Bequest	173	10	0	„ chargeable with the Award of a Prize.
9. Thomas Howard's Bequest	500	0	0	Metropolitan Railway 4 per Cent. Perpetual Preference Stock, chargeable with the Award of a Prize for an Essay.
10. Dr. Cantor's Bequest	4,600	0	0	Invested in Bombay and Baroda Railway Stock (as above) and Ground-rents (costing £2,695 11 3). Interest applied to the Cantor Lectures.
11. " Owen Jones " Memorial Trust	423	0	0	Canada 4 per Cent. Stock, chargeable with the Award of Prizes to Art Students.
12. " Mulready " Trust	105	16	0	South Australia 4 per Cent. Stock, the Interest to be applied to keeping Monument in repair and occasional Prizes to Art Students.
13. Alfred Davis's Bequest	1,953	0	0	Great Indian Peninsula Railway 4 per Cent. Guaranteed Debenture Stock. Interest at the disposal of the Council for promoting the objects of the Society.
14. Accumulated Interest on Trust Funds	400	0	0	On Deposit with Messrs. Coutts and Co.

The Assets, represented by Stock at the Bank of England, and Securities, Cash on Deposit, and Cash balance in hands of Messrs. Coutts and Co., as above set forth, have been duly verified.

B. FRANCIS COBB }
OWEN ROBERTS } *Treasurers.*

ANDREW D. CHADWICK, F.C.A., *Auditor.*

HENRY TRUEMAN WOOD, *Secretary.*

Society's House, Adelphi, 20th June, 1898.

ANNUAL GENERAL MEETING.

The Council hereby give notice that the One Hundred and Forty-fourth Annual General Meeting for the purpose of receiving the Council's Report and Treasurers' Statement of receipts, payments, and expenditure during the past year, and also for the election of officers and new members, will be held in accordance with the By-laws on Wednesday, 29th June, at 4 p.m.

(By order of the Council),

HENRY TRUEMAN WOOD,
Secretary.

CONVERSAZIONE.

The Society's Conversazione was held at the Natural History Museum, Cromwell-road, S.W., on Wednesday evening, 22nd inst.

The Reception was held in the Central Hall of the Museum, by Major-General Sir OWEN TUDOR BURNE, G.C.I.E., K.C.S.I., Chairman, and the following Members of the Council:—Captain W. de W. Abney, C.B., F.R.S., the Attorney-General, G.C.M.G., M.P., Sir Stuart Colvin Bayley, K.C.S.I., Lord Belhaven and Stenton, Mr. Francis Cobb, Mr. Lewis F. Day, Major-Gen. Sir John Donnelly, K.C.B., Mr. Joseph G. Gordon, Mr. W. H. Preece, C.B., F.R.S., Prof. Roberts-Austen, C.B., F.R.S., Lord Strathcona and Mount Royal, G.C.M.G., Mr. W. L. Thomas, and Prof. J. M. Thomson, LL.D., F.R.S.

Promenade Concerts were given by the String Band of the Royal Marine Light Infantry (George Miller, Mus.Bac., conductor) in the Central Hall, and by the Red Hungarian Band (Feher Poldi, leader) in the Bird Gallery.

The number of visitors attending the Conversazione was 1,679.

PRACTICAL EXAMINATIONS IN MUSIC.

The Practical Examinations in Vocal and Instrumental Music will be conducted by Mr. John Farmer, Balliol College, Oxford, and Director of the Harrow Music School, Examiner, and Mr. Ernest Walker, M.A., Mus.Bac., Oxon, and Mr. Burnham Horner (organ), Assistant Examiners, at the House of the Society, and will commence on Monday, 27th June.

EXHIBITION OF ACETYLENE GENERATORS.

The Exhibition of Acetylene Gas Generators was opened at the Imperial Institute, on

Wednesday, the 5th inst., by Major-General Sir Owen Tudor Burne, G.C.I.E., Chairman of the Council of the Society of Arts. Twenty-six generators are shown by 24 exhibitors. The Exhibition was organised by the Imperial Institute at the suggestion of the Acetylene Illuminating Company, who are manufacturers of carbide of calcium at Foyers. The generators have been erected in a temporary iron building, set up for the purpose, in the South-west quadrangle of the Institute, the building being of much the same character as, but on a larger scale than, buildings which might serve to contain generators to be employed for the illumination of country houses. Each apparatus is connected by a separate service pipe to a seven-light gasalier, inside one of the ground floor exhibition galleries of the Institute, so that the lighting power of the gas may be shown. The portion of the gallery, where these gasaliers are fitted, is now entirely illuminated by acetylene. In addition to this, the North Gallery has been devoted to exhibits of generators, lamps, burners, and various appliances used in connection with acetylene illumination, this apparatus not being shown in action. The generators have all been tested by the Committee appointed for the purpose by the Society of Arts, and have only been admitted to the Exhibition after passing the test laid down by the Committee.

In opening the Exhibition, Sir Owen Burne gave a short description of the manner in which the gas was produced from calcium carbide, moistened with water, and spoke favourably of the prospects of the new illuminant for use in situations where coal-gas or electricity could not conveniently be supplied. He also referred to the assistance which had been rendered by the London County Council in placing at the disposal of the Committee the Council's premises in the Harrow-road, for use as a testing station. It is intended to keep the Exhibition open until the end of August.

EFFECT OF THE COTTON SPINNING INDUSTRY IN CHINA UPON THE KINDRED INDUSTRY IN INDIA.

BY WALTER C. WOOD, M.I.M.E.,

Late Examiner in Cotton Spinning to the Victoria Technical Institute, Bombay.

In order to arrive at a true and correct estimate as to what, in the near future, will be the effect of Chinese competition upon the

Indian cotton spinning industry, it will be necessary to compare, in as many ways as possible, the bases upon which this industry is conducted in both countries; and from the more points we can view the subject, the more chances have we in arriving at the truth. In addition to comparing the climate, mills, machinery, and work-people, we must also compare the commercial solidity of the firms, and the ways they have of doing business.

Although Bombay is the great seat of the cotton industry in India, cotton spinning and manufacturing are to be found in many other parts of the Empire. The trade is successfully carried on in Calcutta and Madras, in the Punjab and Central Provinces, in Southern India, and in Ceylon.

But it is not of these mills I wish to speak, as they are employed in spinning yarn for local requirements, or have exclusive markets of their own, and, consequently, will not be effected by this Chinese competition.

Bombay possesses, *par excellence*, all the necessary qualifications for this industry to take deep root and to flourish. Here is the great centre to which Indian grown cotton is sent, and here is by far the largest and most important market in India. During eight months of the year there is practically no rain, and the unique sight of tens of thousands of bales of cotton of all grades may be seen piled up in the open air on the huge cotton green at Colaba. Here it is bought for shipment abroad, and also for the requirements of the adjacent cotton mills.

A comparison of the progress and expansion of the trade during the last twenty years is both interesting and instructive. We find, that in 1877 there were, in the island of Bombay, 31 mills, containing 8-95,204 spindles and 8,433 looms, employing 20,347 workers, and consuming 1-61,220 bales of cotton of 392 lbs. each. In 1896, there were 71 mills, containing 21-86,323 spindles, and 21,335, employing 78,455 workers, and consuming 8-49,678 bales of cotton, also of 392 lbs. each.

Out of a population, at the end of 1896 (before Bombay was decimated by the plague), of 800,000, roughly speaking, it may be safely said that this industry supported, directly and indirectly, one-fourth of the people. In addition to this, its beneficial effects are very far reaching. Immense numbers of workers leave Bombay every year, for a month or more, to visit their native country, taking with them their hard-earned savings, either to invest in

land, or to improve land already in possession of themselves or their families.

It will easily be seen that a large sum of money is thus annually put into circulation in these agricultural districts where, to say the least, there is very little ready cash floating about, as may be judged from the fact that a man's daily wage is two annas only (about twopence). Another benefit to the community is that these thousands of country people are brought immediately into contact with system, order, and punctuality, and have to be amenable to rules and regulations. They are taught to be smart, decisive, and obedient, and can see by the ultimate effect on their own work and wages, how much better it is for them to work systematically, than in their old habits of ease. These people are not natives of Bombay, but come principally from the South Kon Kan (Rutugherry in particular). They are essentially agriculturists, and, as remarked before, either own land themselves, or, through their families, retain their interest in agriculture. From a commercial aspect, this is a distinct disadvantage, for each man has had to serve a sort of apprenticeship, and has only arrived at a skilful state through entailing a certain amount of cost to the concern where he may have been trained. And it does seem a pity that when this raw material should have become of value, it betakes itself again to its native country, and relapses into its former state of uselessness. In order to prevent this loss of trained labour, an experiment is being tried this year, by the Bombay Masters' Association, at the suggestion of Messrs. Tata of Bombay (who are large employers of labour), of importing hands from an entirely new district. Their proposal is to import workers from the North-West Provinces, and in order to give the thing a trial a sum of Rs. 3000 has been voted.

Men, women, and children find employment. The men and boys mind the machines, whilst the children are employed in "doffing bobbins," that is, in taking off the machines the bobbins of full material, and replacing them with empty ones. The women are engaged in reeling the yarn into hanks, in which state it is sold, either to merchants or to consumers. It is interesting to note that the staff varies according to the caste of the proprietors or agents. If a Parsee, for instance, happens to be the managing director, then, in all the important positions, his co-religionists predominate.

The hours worked are from light to dark;

that is, from 6 a.m. to 6 p.m. in the shortest days, and from 5 a.m. to 7 p.m. in the longest days, with half an hour's rest in the middle of the day. Of course, although the machinery is running this length of time, the individual workers are not continuously employed, for they go into the mill compound to take their meals, and to smoke their biddies or native cigarettes, two or three times during the day.

The work is not physically hard. In reality, the principle duty of the workers is to keep an eye on the machines, which have now arrived at such a wonderful state of perfection, that the greatest business they have to do, is to piece up broken ends, and replenish the machines with material when required, and to take away the cotton as it is completed in each process. Inside the mills the temperature is naturally high. The writer has many times taken the variations in rooms at different times of the day, and from these observations it would be safe to say that the heat varies from 90° to 110°, the latter, of course, only during the hottest weather. The natives meet this by discarding clothes, and only wear a piece of cotton cloth round their loins, and do not appear to be much affected by it. One might think that the atmosphere of Bombay would be exceedingly dry, such, however, is not the case, except during the months of December, January, and February, when the north-east monsoon blows, which, being a land wind, makes a great difference in the atmosphere. A great amount of frictional electricity is then generated by the machines, and, consequently, the cotton does not spin nearly as well as when the air is more moist.

As a rule, the mills are very carefully managed. Much more attention to minute detail is paid than in mills at home. In all of them a daily report is made of the previous day's working, containing exact information of the minutest events which may have happened.

They give in detail, for instance, the number of hours the engine worked, number of revolutions it made, number of pounds of coal consumed, the pounds of yarn spun, the amount of waste each machine made, and a host of other particulars. This minute entering into detail is work in which Orientals excel, they take an intense delight in working out everything that can be laid hold of, and reducing it to decimals, and then asking their managers for explanations. They often strain at a gnat, and let thousands of rupees be lost through inability to use plain practical common sense and promptitude.

During the last ten years the cotton industry in Bombay has progressed by leaps and bounds. To an outsider it would indeed appear as if the trade were in a most prosperous condition. On giving the matter a moment's reflection, however, one is tempted to ask oneself this question: Are these new mills the result of *bonâ fide* prosperity in trade, or are they floated as pure speculations?

Now, in India there is a very peculiar way of doing business. Suppose, for instance, three or four persons possessing a few thousand pounds between them desire to float a cotton spinning concern, what do they do? Well, they get together a board of directors, register the company, elect themselves as agents or managing directors. In their articles of association, they take very great care to insert a clause empowering them to charge a quarter of an anna commission on every pound of yarn spun, or of cloth manufactured. This commission is paid to them whether the mill works at a profit or a loss.

I cannot do better than quote from a pamphlet on "Observations on the Management of Cotton Mills, and Suggestions for Amendments in the Indian Company's Act," by Dhunjibhoy D. Dady, published in Bombay in 1894. Paragraph 10 reads as follows:—

"I would here premise that cotton mills are established not as the directors and agents of these concerns would have us believe—and as often expressed in public prints—to promote India's industries. I boldly assert, without fear of being contradicted, that these concerns are floated with the simple object of earning princely commissions. That man must have been a veritable genius who first hit upon the happy thought of charging commission at so much per every pound of yarn and cloth produced by the mills, I repeat emphatically, that were it not for this happy mode of earning commission, whether the companies were working at a profit or at a loss, the directors and agents would never have bothered their brains about promoting India's industries. They would have soon left India's industries to go to the walls for what they cared."

Then, again, it often happens that the directors and agents are unable to raise sufficient capital to pay for the buildings and machinery, and to work the concerns. In this case debenture shares are created, and loans are raised at a high rate of interest. With the result, that what profit the mill had made goes to the agents, in shape of commissions, and in interest to loan capital. The writer calls to mind a case in which one lac of rupees annually was swallowed up in this manner, whilst the poor shareholders got nothing.

Many mills in Bombay are floated on these unsound lines, and the only conclusion one can arrive at, after carefully perusing their respective balance-sheets, is that if a period of prolonged badness of trade were to set in, they would fall from their insecure foundations, and general ruin would be the result. Indeed, the bad time they have just gone through on account of the plague, when nine-tenths of the hands fled from Bombay, must very seriously have effected some of them. The agents kept as much of the machinery running as they could, and had to pay 50 per cent. more wages to the few workers who remained behind. Their idea was to keep the mills working at any cost with the following results—less production, worse quality, greater wastage, machinery suffering through unskilful management. Some mills were entirely closed for a few weeks, but the majority managed to keep a part of the machinery working.

In addition to the agents making princely incomes from these concerns, many of their relations or friends manage to come in for some remarkably good pickings. It is really surprising what a number of separate and distinct businesses can be created, hanging on to and living upon the mills. You have, for instance, the cotton selector, the cotton broker, the muccadum or man who carts the cotton from the market to the mill, a man who makes a very respectable fortune in a very few years. Then there is the coal broker, the coal watcher, the coal muccadum, in fact where a department can be created it is, and the happy possessor of that plum soon becomes rich and happy.

As to the mills and machinery, they are fitted with the latest improvements in engines, boilers, and machinery in general. No expense is spared to equip them with the most modern appliances. They can fully bear the closest comparison with the most up-to-date concerns at home. The work-people are skilled and attentive, and use the machinery well. In most concerns there is a European manager who acts as a sort of supervisor. It is a surprising fact, that although the natives have been familiar, and have become expert in the use of cotton spinning machinery for over thirty years, they have practically done nothing themselves in making improvements. They accept and appreciate new ideas as they are brought out, yet they seem incapable of originating anything themselves—an Oriental trait. They are wonderful copyists, but poor originators.

The oldest cotton spinning mill in China has

not been erected more than about nine years. It is true that a large mill was erected by Li Hung Chang, in Shanghai, a few years before then, but this mill was unfortunately burned.

Since 1891, great progress has been made. In Shanghai alone, there are no less than eleven cotton mills. In the first six months of 1897 five new concerns commenced working, whilst up country several mills are already working, and there are numerous inquiries from projected new companies. So that it seems as if this industry had now established itself on a firm basis.

Naturally the first concerns were founded and worked by Chinese, with European supervision over the machinery. They, themselves, superintended the commercial department, so far with anything but satisfactory results.

In his own opinion, John Chinaman is a wonderful man, even if he does most things in exactly the opposite way to what he should. He has neither the faintest idea of taking stock nor of balancing his books at the end of the year as he ought to do.

The Chinese have only one holiday in the year, and that is at their new year, which date is movable, but generally falls sometime in February. This is the time they square up everything, and pay off all their debts. Any one not being able to pay all his accounts, and to start the new year with a clean sheet, is posted as a defaulter, and is looked upon with suspicion by everyone. It is considered a family disgrace not to pay everyone up at that time. Naturally the people are preparing some weeks before hand to arrange their business, so that they can clear off all outstanding accounts and be in a position to start *de novo*. From what one can see, this is the time John can tell whether he has made a profit or a loss in his business during the past year. He pays all his debts, and then sees how much money he has left, and so estimates his gains or losses. As we before remarked, the cotton spinning industry has not turned out a very profitable speculation when under exclusive Chinese management. The fact is, John tried to run before he had learned to walk. He was certain he knew how to manage a large concern, though he had had no previous training, and, in fact, knew far better than the Europeans he had specially engaged to teach him. The only natural results followed: he lost money and gained sense, with the result that most of the mills owned by Chinese in Shanghai either have been, or are, now in

process of being transferred to European companies, to be worked and managed on exclusive European lines. One thing John intensely dislikes, and indeed seems utterly unable to do—that is, to look after “little things.” He has only one spot where he can be touched, and that is—his pocket. He has a decided objection to spend money, and an all-consuming desire to make it. In furtherance of this weakness, he makes up his mind he will not pay high wages—and he does not. He engages numbers of what we should call “look-see” men; that is, gentlemen who are employed in walking round the mills to “look-see” if others are attending to their work. From a close and careful observation of these men, their commercial value would not be one dollar per dozen. “Eyes have they, but see not; ears have they, but hear not.” The wages of these gentlemen vary from 20 dollars per month down to 6 dollars. Average them at 10 dollars; the value of the dollar to-day is 2s., which gives them some 5s. per week of wages. It must be borne in mind that they are married men, and have to support families on this small sum. When one looks at the gorgeous silks and satins in which they are arrayed, one is tempted to ask one’s self, How do they manage to dress and live on such pay? To an outsider this would be a subject for anxious inquiry, but to one who knows, the answer is given in one word, “Squeeze,” with a big capital “S.”

Yes. Squeeze is the the beginning and the ending of all business in China. It is the life thought of the proprietor’s servant, who receives some six dollars a month as pay, and who somehow or other manages to keep a wife and family in good condition, can dress in “crushed strawberry” silk breeches, and a gorgeous lavender-coloured satin coat. You may rack your brains in trying to elucidate the problem as to how it is done, and find no answer. Perhaps, however, during the process of investigation, you may want to see his master on business. He cannot be approached, for he is a mandarin of sorts, without your being announced by his servant. Having sent in your card with a request that you wish to see him on a matter of important business, the servant returns and says he is very sorry, his master is asleep and cannot be awakened, or he is sick and cannot be seen. You return next day, when the same or other plausible answer is given, and so on, till you wake up to the truth, and pay. Then you can understand the silks and

satins, and other trifles which were a mystery before.

And so it is in all grades, from the highest to the lowest, and from the richest to the poorest, the great problem is—How can we get a squeeze? Everything has to be paid for. It is a game of chance; you approach the official—whoever he may be, and intimate to him you are wishful for service, and what you are prepared to pay. It is a case of cash down; you have to part there and then, and on the strength of this “comshaw,” or squeeze, he approaches the principal, and represents your case to him. If he is eloquent, or has sufficient influence with his master, you obtain employment; if, on the other hand, he fails, you have paid your squeeze and lost. You have had your chance, and missed. One thing, however, remains—the squeeze is never returned.

Not only upon men is there a squeeze, but upon everything that is bought. Only the other day, having occasion to check eight large rolls of leather belting which had been purchased from a Chinese store, each roll was found to be 40 feet short in length; in all, 320 feet. On referring to the storekeeper’s books, everything was found to have been checked and entered as correct. But where were the 320 feet? There is only one answer: they had gone in squeeze.

The first thing which would strike an outsider on walking through one of the mills under Chinese management, is the excessive dirtiness around him. It is a fact that a Chinaman cannot see dirt. He will actually fall down through slipping on a dirty, greasy floor, and next day repeat the process, without it ever striking him to remove the cause. They are dirty, filthy, alike from the highest to the lowest. Dirt and disorder is the last thing they can or will see. Their houses are never cleaned, they have no comforts and not many wants.

That nation which has the most wants or desires is the most civilised—China has very few. Her great desire is to be left alone in her dirt and squalor and to be allowed to go on as she has gone on for centuries past. She cannot bear the poking up she is now receiving at the hand of the foreigners. When, however, John has been thoroughly aroused and brought into line he is anything but a fool.

In making a comparison between the work-people, a wonderful difference is at once noticed between the Hindoos and Chinese. The customs, habits, and manner of living at once declare

themselves in the different races. Naturally India to-day has by far the most skilled workers, but I am most decidedly of opinion that in a few years' time the Chinese will be equal to them in every respect. The present state of efficiency in the operations at home was not arrived at in a day, or even a year. They owe their foremost position as expert workmen to being trained from early childhood. China, in this respect, will be placed at a greater advantage than India, because the Hindoos only come to Bombay for a time, and then return to their native country to retire upon the money they may have saved. On the other hand, Chinese labour is recruited from the immediate districts in which the mills have been erected. The result of this is that several members of the same family find employment in the same concern as at home.

So great has been the demand for labour of late through such a number of new concerns having been started, that fully grown and old people have been engaged. Naturally, these people are too old to become expert and quick, and fail to give proper results. It is to the children who are now learning their business we have to look; and we may say that the greatest and most important work those Europeans have who are in charge of the mills in China is to break in this raw material, and to reduce it from its original condition of dirt and disorder to system and order.

Then, again, there is no Factory Act in China, nor any factory inspection to put a limit to the number of hours the people work, or to the age at which they commence to work. The writer has known many cases where children of not more than 10 years of age have worked 16 hours at one spell, with not more than two stoppages of 15 minutes each during that time. In some of the mills the engines work $22\frac{1}{2}$ hours out of the 24. Work is carried on night and day, with two shifts of hands. Those on day duty begin at 6.30 in the morning and work till 6 p.m. On Sunday, those hands who have worked all Saturday night have to clean the machinery, which takes till 10 or 11 o'clock, so that they have a long spell of work of something like 16 hours.

With regard to the raw material, the cotton, the condition in which it is bought and delivered to the mills, is very different in each country. In India, you can go to the cotton market, select your purchase, and have it delivered to the mills in a condition freed from seed and leaf and pressed in bales, just as you can do in Liverpool. In China there are no

presses worth speaking of. You can buy cotton in Shanghai which has been ginned at some of the mills (that is, it has been freed from seed and leaf), but the greater proportion comes down from the grower up country in bags made of rushes, exactly in the state it has been plucked from the plants. Many of the mill employ agents to buy direct from the farmer who ship it to Shanghai in boats *via* the canals, creeks, and rivers which are the great means of communication.

The cotton is of a fine staple and is of a very white colour. It is very free from broken leaf seed sand, and other impurities. In staple it varies, being very similar in length to Indian varieties. The shorter stapled cottons correspond to Bengal cotton, whilst the longer one are about equal to those grown in Guzerat. Here the comparison ceases, for as soon as it is put into work an expert at once detects a difference. By treating it exactly as Indian cotton is done, a very soft and unmarketable yarn is produced. On placing a few fibres under the microscope for examination, it is at once perceived that there are far fewer convolutions, and that the body of the fibre is finer and flatter than in Indian varieties. The result of this is, that owing to this fewness of convolutions, the individual fibres do not twist round each other, or grasp each other, but have a tendency to lie parallel to one another instead of twisting into a firm strand. To sum up, China cotton requires at least 20 per cent. more turns of twist to produce the same strength of yarn which Indian cotton gives.

A few remarks on the cultivation of Indian cotton may not be uninteresting. It is a fact that Indian grown cotton does not improve in quality, in cleanliness, and in length of staple or in yield per acre, as one would naturally expect. There does not appear to be any attempt made to improve its cultivation by selecting the best of seeds or by fertilizing the land. Why? The answer is very short and very simple. The land belongs to the ryots, and has most likely been in their families for generations. Now, everyone knows that the poor ryot is a man who cannot make both ends meet, and mortgages his crops long before they are ripe. In case of sickness or of famine, or when there is a wedding in his family, he needs some ready cash, and, consequently, goes to the marwarri, or money-lender, who kindly obliges him, and soon loads the original amount, with interest and compound interest, to such an extent that the poor ryot can never get free from him. Nominally

the owner of the land, he is in reality nothing more than the servant of the moneylender. He lives from day to day—a never ending round of toil; his hours of work are from sunrise to sunset; he has no aspirations, nor any desire to free himself and to get on; he is just as his father was, and his children will have no other ambition, than to be just as he is. And thus it is, year in and year out, the same round of toil, and of labour, and of hopeless debt ever hangs over him, and a life is lived with no incentive to better himself by improving either the quality or the yield of his crops.

The ground is tilled with the same rude, wooden ploughs, shod with a tip of iron; and the seed is taken from the previous year's cotton, whether it was of good or of bad quality matters not, in exactly the same way it was centuries ago.

In China you can depend upon getting the pure and unadulterated article you purchase, because it undergoes all its processes under your own observation. On the other hand, in India, the natives are rather more astute. They have arrived at the knowledge of the truth that it is easier and more profitable to grow sand than cotton, and that if they can mix a poor with a better grade along with a sprinkling of sand, why a good day's work has been. As regards the future outlook of this new industry in China and the effect of its competing with India, the case appears almost parallel to that of Lancashire and Bombay some years ago. Lancashire lost her trade in low numbers in the East for the simple reason that she could not compete with Bombay with its cotton grown on the spot and its cheap labour. It seems very probable that Bombay will just take the place Lancashire did, and she will have to do what her old rival did—she will have to find new markets. With a population of over 280,000,000 at her doors it does not seem unreasonable to think that she could easily find an outlet for her manufactures in supplying yarn for the clothing of her teeming millions.

Ought we not to look upon this development with feelings of pleasure and not with feelings of antagonism. For is not each new mill or manufactory which is erected a great civiliser and a great teacher, and will not these new industries play a very important part in the awakening of China? A remark made to me by a mandarin, as he was inspecting a large cotton mill, shows that these industrial concerns do arouse within them feelings of sorrow for their country. "Ah," said he in a tone of

sadness, "This is the work of foreigners, we could not do these things." If high officials begin to think thus, and can see how backward they are among nations, it is certain then that every new mill erected will play some part in helping on the time when China shall become awakened from the great sleep which has overcome her.

BEET SUGAR.

The following particulars respecting the immense growth in the production of beet sugar are taken from an original article on "Sugar" in the *Pall Mall Gazette* :—

"Beet is usually grown on a large scale, and the produce of a considerable area is sent to a great central factory, where the juice is expressed, and the pulp and rinds returned to the grower. The price paid to the grower by the manufacturer for the juice is generally about 16s. per ton of beet. The grower, therefore, realises from his crop per acre—

For price of ten tons sugar, say	£8	0	0
For two tons of pulp at £3	6	0	0
Total per acre	£14	0	0

The following figures, perhaps, will give in a concrete form some idea of the present dimensions of the beet-sugar industry. It is estimated that there are now on the Continent under beet 5,000,000 acres. These produce about 50,000,000 tons of beet, which, on an average of one ton of sugar to ten tons of beet, give 5,000,000 tons of sugar. The pulp, or "cake," as it is usually called, left after the juice is expressed amounts to one-fifth of the original weight of the beet, or ten tons of beet give two tons of cake. Now one ton of this cake is estimated to have the same feeding value as a ton of good hay, and therefore may be considered as worth £3 per ton. It results, therefore, that the money value of the beet crop of Europe is as under :—

Sugar produced, 5,000,000 tons at £8..	£40,000,000
Cake produced, 10,000,000 tons at £3..	30,000,000
Total	£70,000,000

Most continental sugar-producing countries raise taxes on their home consumption of sugar :—

In Austria the tax is about	£12	per ton.
In Belgium " "	25	"
In Holland " "	6	"
In France " "	25	"

It is difficult to arrive at the amount of sugar consumed in countries other than France, but there the consumption is known to be 520,000 tons, and the octroi duty on this at £25 per ton, £12,900,000; 420 distillers using molasses pay an excise duty of £10,000,000, so that France raises the enormous revenue from sugar of £22,900,000.

The price of sugar has fluctuated very greatly in the last fifty years, but of course the general tendency has been steadily downwards. Between 1850-60 it varied from £58 to £60 per ton. In 1894-95 it fell as low as £8 10s., and at present is about £10 10s. At this price, which probably will fall even lower if the production goes on increasing at its present rate, how can cane sugar compete with beet? The former can be produced in the West Indian Islands, it is believed on good authority, at about £6 per ton. Freight, package, insurance, and other charges will make its cost in England £8 per ton. But quite 80 per cent. of the planters are in the hands of financial houses and banks, whose interest on mortgages and advances will add another £1 10s. per ton to the cost, leaving no profit to the grower."

The importance attached to the new industry of beet-sugar manufacturing and refining in some parts of California may be judged of by the following remarkable dimensions of the new establishment now being constructed at Salinas, in that State, which are taken from *Invention*:—Main building, 582 ft. long, 102 ft. wide, and 5 storeys high, the materials consisting of 3,500 tons of steel, 4,000,000 bricks, and 800 square of slate; boilerhouse, 559 ft. long, 68 ft. wide, and 22 ft. high, the material and contents comprising nearly 1,000,000 bricks, 12 boilers, 4 economisers, 2 steel smokestacks, 216 ft. high, 13 ft. diameter, each stack with base weighing 1,000 tons; machine shop and carpenter's shop, 559 ft. long, 40 ft. wide, and 22 ft. high, and containing about 600,000 bricks; water required to keep mill running, 13,000,000 gallons per day; will consume about 1,200 gallons of oil daily—that is, in 24 hours—or its equivalent in wood or coal, and will cut 3,000 tons of beets per day of 24 hours. The expected daily sugar product of this vast establishment is about 450 tons.

GREENWICH OBSERVATORY.

The Astronomer-Royal's Report to the Board of Visitors, which was read at the Annual Visitation of the Royal Observatory, on the 4th inst., is divided under the following headings:—I. Buildings and grounds, movable property and library. II. Astronomical observations. III. Spectroscopic and heliographical observations. IV. Magnetic observations. V. Meteorological observations. VI. Printing and distribution of Greenwich publications. VII. Chronometers, time signals, longitude operations, &c. VIII. Personal establishment.

Under heading IV. the Astronomer-Royal writes:—

Small agitations, due to the running of trains on the South London Electric Railway, the nearest point of which is at a distance of $4\frac{1}{4}$ miles from the Observatory, can be seen in the horizontal force and vertical forces, synchronising with the disturbances in the earth current registers. These small effects can be

traced from the year 1890, but owing to the distance of this electric railway they do not seriously interfere with the magnetic registers. A proposal which has been recently made in a Bill before Parliament to use electricity for a proposed tram-line in the neighbourhood of the Deptford cattle market, at a much less distance from the Observatory ($1\frac{1}{4}$ miles) would, probably, if carried out, have destroyed the value of our magnetic records, and it has been successfully opposed.

Under V. :—

The new sunshine recorder which has been in use since the beginning of 1897, gave for that year total record of 1,543 hours of sunshine, as compared with 1,575 hours recorded at Kew, and 1,279 hours at Bunhill-row. The monthly totals were—

January	19·8
February	34·1
March	123·4
April	144·7
May	251·6
June	178·3
July	252·7
August	219·8
September	114·5
October	111·7
November	41·7
December	50·3

The number of hours of bright sunshine recorded during the twelve months ending 1898, April 30, by the Campbell-Stokes instrument was 1,529 out of the 4,454 hours, during which the sun was above the horizon, so that the mean proportion of sunshine for the year was 0·343, constant sunshine being represented by 1.

The mean temperature of the year 1897 was 50·3° being 0·9° above the average for the 50 years 1841-1890.

During the twelve months ending 1898, April 30, the highest daily temperature in the shade recorded on the open stand was 90·2° on June 24. The highest reading recorded in the Stevenson screen was 87·4° on the same day. The monthly mean temperatures were in excess of their corresponding averages in every month with the exception of May, September, and March. In January, the excess amounted to 5°, the mean temperature for that month being 43·6°. In the preceding 57 years there is one instance only of higher mean temperature occurring in January, viz. in 1884, when it was 43·9°. A mean value equal to the present January value (43·6°) was also recorded in two other years (1875 and 1890). The winter of 1897-1898 was remarkably mild throughout, and the temperature of the air fell to freezing point (or below) on 29 days only,—10 of these occurring in March and in December. The lowest temperature recorded during the winter was 23·3° on December 24. [The lowest temperature recorded in January was 30°. The mean temperature for the five months 1897-

October, to 1898, February, was $44^{\circ}6'$, being $2^{\circ}4'$ in excess of the average value. During the whole period of 57 years (1841 to 1897) this value has only been exceeded three times, viz., in the winter of 1876-1877, when the mean for the five months was $45^{\circ}8'$, in the winter of 1845-1846, when it was $44^{\circ}8'$, and in the winter of 1865-1866, when it was $44^{\circ}7'$. A mean value of $44^{\circ}6'$ (the same as that for the present year) was also recorded in the winter of 1848-1849, and in that of 1868-1869.

The rainfall for the year ending 1898, April 30, was 17.33 inches, being 7.21 inches less than the 50 year average. The number of rainy days was only 149. This is a very small annual rainfall; the three smallest falls during the preceding fifty years being 16.38 inches in 1864, 17.61 inches in 1867, and 17.70 inches in 1858.

ART METAL EXHIBITION.

The Exhibition of Art Metal Work at the Royal Aquarium, Westminster, which was opened on the 27th May, and is announced to close on the 30th inst., consists of two sections, viz., a loan collection in St. Stephen's Hall, and an industrial collection in the galleries and on the ground floor of the building.

The loan collection is very extensive, Her Majesty, the Duke of Norfolk, and the Duke of Westminster being among the largest contributors. Other collections of armour are lent by the Middle Temple, Lord De L'Isle, Lord Zouche, the Royal Artillery Institution, Sir Noel Paton, Sir T. Gibson Carmichael, and several members of the Kernoozers Club. The Beckett cup, helmets lent by the Deans of Westminster and Windsor, and the Mayor of Coventry are among the more striking objects; while a matchless series of fire-arms contributed by the Queen, Major Farquharson, Lord Archibald Campbell, and others, make a remarkable exhibition.

In addition to the collection of armour, fire-arms, &c., there is a noteworthy series of cast-iron firebacks and other specimens of old Sussex ironwork of the 16th, 17th, and 18th centuries in a side gallery. Some of these castings are artistic and very sharp in outline, and especially is this the case with the royal arms which are found on several of them. Others are debased in design and execution. These firebacks are in many instances dated. One of the earliest of these consists of an armorial with helmet crest and mantling, dated 1606, which is lent by Lord Leonfield (No. 14). Other dated firebacks are of 1621 (No. 21), 1622 (No. 20), 1632 (No. 23), 1636 (No. 29), 1644 (No. 17), 1647 (No. 12), 1650 (Nos. 32 and 38), 1697 (Nos. 26 and 57). Members of the Society of Arts will remember a paper on "Cast Iron and its Treatment for Artistic Purposes," which Mr. W. R. Lethaby read before the Applied Art Section in February, 1890. In this paper special notice was taken of these firebacks, and since then much attention has been directed to them. Lately Mr. Starkie

Gardner read a paper upon the subject before the Society of Antiquaries, and the gathering together of this large collection is chiefly due to his industry.

In this same gallery are two cases containing many metal objects of great interest lent by Lady Dorothy Neville. Among these objects are old rush holders with tinder boxes, candlesticks, lamps, snuffers, tongs, toasting forks, keys, scissors, &c.

The case No. 4 in St. Stephen's Hall contains some splendid armour lent by the Queen. Perhaps the finest example is a demi-suit of bright steel armour, with bands of damascened gold strap work with medallions, made for the great Earl of Essex. Another fine example is the tilting suit of Henry, Prince of Wales, son of James I., in bright steel damascened and chased in gold with the national emblems, thistle and rose and fleur de lys of France, between these emblems run panels of elaborate strap work with the initials H.P. surmounted by a crown. There is a curious misprint in the catalogue where it is stated that Prince Henry was the son of Edward the First!

In case No. 3 is a sword with relic pommel and drooping guillons inlaid in lozenge ornament in gold, silver, and copper, lent by Mr. Morgan Williams. This was found in the Thames at Westminster, and is said to be of the 9th century.

The other cases contain a remarkable collection of historical armour, and many specially fine breastplates. Case 19 contains a curious collection of japanned metal cups, urns, candlesticks, kettles, &c., principally of Dutch manufacture. Lent by Mr. J. H. Fitzhenry.

Case No. 23 contains wrought-iron keys, locks, &c. Case No. 24 contains a collection of pewter objects, lent by Mr. J. H. Fitzhenry, Mr. J. Washington Browne, and Mr. Carl Krall.

The collection of fowling pieces, muskets, pistols, rifles, swords, rapiers, and cutlases, is very complete. Cases Nos. 3, 36, and 37 contain a remarkable collection of flintlocks, snaphance, wheel, match and other locks. The two-handed sword of the Earl of Leicester is lent from Penshurst Castle, by Lord de Lisle and Dudley.

Mr. Garraway Rice lends among other curiosities the monogram H.M.S., in wrought-iron, from the railings of the tomb formerly in the Churchyard of Hampton, Middlesex, of Huntington Shaw, of St. James's, Westminster, blacksmith, born at Nottingham, 1660 (died 1710). Although Shaw's is such a well-known name, so little is recorded of his history that there is no life of him to be found in the "Dictionary of National Biography."

Among the industrial exhibits are objects in silver, copper, brass, and pewter, but wrought iron-work occupies the most important position. On the ground floor are fine wrought-iron gates by Messrs. J. Starkie Gardner and Co., Edgar Keeling, Teale and Co., Lindsay Neal and Co., Hill and Smith, &c.

A very distinctive feature of the Exhibition is the great variety in the designs for fire-grates shown by the Carron Company, the Coalbrookdale Company, Falkirk Company, Feetham and Co., Potter and Sons, Longden and Co., Steel and Gar-

land, and others. Messrs. Longden and Co. show a fireplace of polished ironwork with camelot tile framing, the whole designed by Mr. H. Ricardo.

Messrs. Barkentin and Krall have a fine show of ecclesiastical work, and Messrs. Potter and Sons some eagle lecterns, one being copied from an original found in the lake of Lord Byron's seat, Newstead Abbey. Amongst Messrs. Potter's exhibits is a fine piece of old German ironwork dated 1710, consisting of balcony and gates, the property of H.R.H. the Princess Louise, Marchioness of Lorne.

The display of electric light fittings by Perry, Miller, Litchfield, Benson, Tayler Smith, Potter, Strode, Drake and Gorham, and others, is very extensive.

There is much more of interest that could be mentioned, but it is only necessary to say that the Exhibition shows that the manufacturers of to-day are attempting to emulate the triumphs of the metal workers of old, and are producing a great variety of designs of a much higher character than was to be obtained some years back.

The Hon. Secretary of the Exhibition is Mr. Starkie Gardner.

Obituary.

GENERAL WOODTHORPE.—Major-General Robert Gossett Woodthorpe, R.E., C.B., Deputy-Surveyor-General of India, who died in Calcutta, on May 26, at the age of 53, was a member of the Society, and in 1896 read before the Indian Section a valuable paper on "The Shan Hills: their Peoples and Products." The Right Hon. G. N. Curzon, who presided at the meeting, said that Colonel Woodthorpe "was a man of almost unique experience in both sides of India." He was a talented draughtsman, and the paper was illustrated by a very interesting collection of original sketches. He joined the service in 1865, and had been a member of the Survey Department 27 years. He was engaged on special duty with the Gilgit Mission of 1885, and attached to the important Mekong Commission of 1894. The official record of his war services is as follows:—"Served with the Lushai Expedition in 1871-72 (medal). Served in the Afghan War of 1878-80, and was present at the capture of the Peiwar Kotal, in the engagement at Mattoon, in the operations round Cabul in December, 1879 (mentioned in despatches), and in the engagement at Shekabad (mentioned in despatches, Brevets of Major and Lieutenant-Colonel, medal with two clasps). Served with the Akka Expedition in 1883-84, and with the Chitral Expedition in 1885-86. Served with the Burmese Expedition in 1886-87 on Survey duty (mentioned in despatches, C.B., and clasp)."

SIR JAMES DOUGLASS, F.R.S.—Sir Jas. Douglass, late Engineer in Chief to the Trinity-house, who died

at Bonchurch, Isle of Wight, on the 19th inst., was member of the Society of Arts for many years, and was elected a member of Council in 1891. He was born at Bow, Middlesex, on October 16, 1826, the son of Mr. Nicholas Douglass, of Stella-house Penzance, by the daughter of Mr. J. Douglass, of Winlaton, county Durham. He received a regular training in civil and mechanical engineering, and his first important employment was in 1847, as assistant engineer to his father, who was superintending engineer to the Trinity-house, and was then engaged in erecting the lighthouse on the Bishop, the western-most of the Scilly rocks. He was next appointed resident engineer in sole charge at the erection of the light house on the chief rock of the dangerous group of the Smalls, off Milford Haven. In 1862, on the death of Mr. James Walker, F.R.S., engineer-in-chief to the Trinity-house, Mr. Douglass was appointed to succeed him. During his tenure of the post he carried out many important engineering works both at home and abroad, such as the Wolf, Longships, Great and Little Basses, Eddystone, and Muricoy lighthouses, and he effected numerous technical improvements connected with lighthouses and their illuminating apparatus, as well as in buoys and beacons. On the completion of the present Eddystone lighthouse, in 1882, he received the honour of knighthood. Sir James Douglass was in favour of oil illuminants in lighthouses, for the development of which he devised special apparatus. In 1886 and 1892, Mr. E. Price Edwards described the experiments with this in papers on "Lighthouse Illuminants at the South Foreland," and on "Burning Oils for Lighthouses and Lightships."

MEETINGS FOR THE ENSUING WEEK.

TUESDAY, JUNE 28.—Medical and Chirurgical, 20, Hanover-square, W., 8½ p.m.

Statistical (in the Theatre of the United Service Institution), Whitehall, S.W., 5 p.m. Annual General Meeting.

Photographic, 12, Hanover-square, W., 8 p.m.

WEDNESDAY, JUNE 29.—SOCIETY OF ARTS, John-street, Adelphi, W.C., 4 p.m. Annual General Meeting.

Japan Society, 20, Hanover-square, W., 8½ p.m. Mr. W. E. Aston, "The Classical Literature of Japan."

United Service Institution, Whitehall, S.W., 3 p.m. Colonel W. N. Lockyer, "Personal Reminiscences of the Evolution of Small Arms and Machine Guns from the year 1863 up to the present day."

British Astronomical, University College, W.C., 5 p.m.

THURSDAY, JUNE 30.—Linnean, Burlington-house, W., 8 p.m.

1. Sir D. Brandis, "A Revision of the Genus *Elaeocarpus*, Linn." 2. Mr. A. W. Waters, "Observations on the *Membraniporidae*, a family of Marine Bryozoa." 3. Miss Ethel S. Barten, "The Fruit of *Chnoospora fastigiata*, J. Agardh."

FRIDAY, JULY 1.—Geologists' Association, University College, W.C., 8 p.m.

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FRIDAY, JULY 1, 1898.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Proceedings of the Society.****ANNUAL GENERAL MEETING.**

The Annual General Meeting, for receiving the Report of the Council, and the Treasurer's Statement of Receipts, Payments, and Expenditure during the past year, and also for the Election of Officers, was held in accordance with the By-laws, on Wednesday last, the 29th inst., at 4 p.m. Major-General Sir OWEN TUDOR BURNE, G.C.I.E., K.C.S.I., Chairman of the Council, in the chair.

The SECRETARY read the notice convening the meeting, and the minutes of the last annual meeting.

The following candidates were proposed, balloted for, and duly elected members of the Society:—

- Berrington, Ernest, Graiseley, Wolverhampton.
 Brunner, Sir John T., Bart., M.P., 9 Ennismore-gardens, S.W.
 Buckwell, George William, Board of Trade Offices, Custom-house-arcade, Liverpool.
 Carroll, Edward Brotherton, Oriental Club, Hanover-square, W.
 Clarke, Thomas B., 406, Oxford-street, W.
 English, Frederick Alexander, Addington - park, Croydon.
 Jones, Will, Hope Bank, Lancaster-road, Pendleton, Manchester.
 Kenning, George, Upper Sydenham, S.E.
 King, Brig.-Surg. Lt.-Col. Sir George, K.C.I.E., LL.D., F.R.S., care of Messrs. Grindlay and Co., 55, Parliament-street, S.W.
 Maddox, Arnold G., 184, Malpas-road, S.E.
 Pease, Alfred John, Birch-avenue, Talbot-road, Old Trafford, Manchester.
 Playfair, Sir Patrick, C.I.E., 5, Lyon's Range, Calcutta, India.
 Pocklington, Henry, 20, Park-row, Leeds.
 Quirk, Charles James, 16, Westmoreland - street, Dublin.

Ralli, Stephen A., 25, Finsbury-circus, E.C.
 Sharp, Archibald, 47, Victoria-street, S.W.
 Smith, Isaac, Mount Hooton-house, Nottingham.
 Stansfield-Brun, John, Church - park, Oystermouth, and Turleigh-hall, Wilts.

The CHAIRMAN nominated Mr. John Jewell Vezey and Mr. Frank Cundall scrutineers, and declared the ballot open.

The SECRETARY then read the following

REPORT OF COUNCIL.**I.—ORDINARY MEETINGS.**

In accordance with the usual practice, the Chairman of the Council, Major-General Sir Owen Tudor Burne, opened the session with an address. On the previous occasion, last year, the Chairman selected India for his special topic; for the Session which has just been completed, he devoted his address to a review of the growth and present position of the "Arts, Manufactures, and Commerce of our Colonies."

At the first meeting of the session, after the Opening Address was delivered, Professor Douglas read a paper on "The Progress of Metallurgy and Metal Mining in America during the last Half Century." In it he may be said to have supplemented his recent course of Cantor lectures on American Metallurgy, and laid special stress on those points in which he considered American practice to be in advance of that of the old country. On the whole, Professor Douglas left the impression that he considered American practice to be distinctly superior to English, but this view was rather controverted in the discussion which followed his paper. A fortnight later Mr. Bennett H. Brough gave an account of "The Mining and Metallurgical Industries of Sweden as shown at the Stockholm Exhibition," at that time just closed. On previous occasions Mr. Brough has described to the Society the metallurgical sections of the exhibitions at Budapest in 1885, Barcelona in 1888, and Kimberley in 1893. The Stockholm exhibition was almost entirely devoted to those special industries, and, consequently afforded an excellent opportunity for a review of their present condition.

In the other meeting which was held before the Christmas recess, Professor Leonard Waldo, who read a valuable paper in 1886 on American watchmaking, gave an account of "The

Theory and Practice of the Manufacture of the Bicycle in America." This was one of two valuable papers on the subject, for at the end of the session Mr. J. K. Starley, who is well known for the very large share which he has taken in the development of the modern cycle, gave an account of "The Evolution of the Cycle." In the former paper, Professor Waldo showed how thoroughly systematised the manufacture of bicycles in America now is, and described the elaborate machinery which has been laid down for the purpose by the Pope Manufacturing Company, at Hartford, Connecticut. One of the peculiar features of the manufacture is the very complete system of tests which has been devised for ensuring the strength of the different parts of the machine. Professor Waldo also described the new method of construction adopted by the Company, in which a shaft with bevel gearing takes the place of the ordinary chain running over a pair of chain wheels, by which power is transmitted from the crank axle to the hind wheel of the machine. Such a method of transmitting power can only be employed when the bevelled wheels are cut with the utmost accuracy, and Professor Waldo stated that the machinery now used for this purpose in America had got over this first and greatest difficulty. Mr. Starley's paper was mainly historical. It gave a clear and careful account of the various stages by which the modern bicycle has been evolved, if not from the ancient hobby horse, at all events from the original "bone-shaker" of Lallemont, produced about 1865. It is a useful thing that the history of an invention should be put on record by the original inventor, and in any future account of the origin of the safety bicycle, Mr. Starley's paper will certainly have to be largely drawn upon.

Three papers dealt with subjects of a more or less photographic character. Mr. Eric Bruce gave an account of the ingenious apparatus which he has devised for what he terms "The Projection of Luminous Objects in Space." An ordinary magic-lantern picture is projected upon a revolving wheel or lath, the rapidity of the revolution being such as to enable the whole picture to be seen in consequence of the "persistence of vision," while the moving lath does not entirely obscure any object in front of which it is placed. Various curious effects may be thus produced which will probably be available for stage purposes. Mr. Jules Fuerst described "The Cinematograph" constructed by Messrs. Lumière, and gave

numerous illustrations of what are popularly termed "animated photographs," certainly the most remarkable of the recent development of photography. Captain Abney, in his paper on "Photography and Colour Printing," gave an account of the application of photographic methods to the selection of those particular tints which, by their proper combination, can be made to give all the necessary hues for the production of pictures in colour. The process of three-colour printing, though it has long been known, and has for long been the object of research on the part of many earnest workers, has only of late been practically developed, or come into actual commercial employment.

Only one paper during the session was devoted to a sanitary question—that by Dr. Rideal on "The Purification of Sewage by Bacteria." The actual nature of the action of bacteria on sewage has only lately become an object of study, but its practical development promises results of very great importance in the immediate future. Dr. Rideal gave a very clear account of the position which the subject has reached, and showed how great the practical usefulness of the methods adopted was likely to become.

In contrast to what has been the programme of recent sessions, only a single paper was devoted to a subject of an electrical nature—that by Professor Silvanus Thompson on "Telegraphy across Space." Professor Thompson gave a most lucid exposition of the different methods which have been adopted for transmitting telegraphic signals without wires being laid between the two points between which the communications are to be sent and succeeded in making a very difficult subject intelligible to a general audience.

Two papers dealt with economic matters. Mr. Provand, in his paper on "Compensation to Workmen," discussed the recent Employers' Liability Act; and Mr. Iselin, in his paper on "The Protection of Industrial Property," described the objects and methods of the International Association for the Protection of Industrial Property, which has just held its Congress in the rooms of the Society.

Professor Ewing, in his paper on "Linde's Method of Producing Extreme Cold and Liquefying Air," described the remarkable regenerative method which Dr. Linde has devised, and indicated some of the purposes to which it was likely to be applied in practice. It seems hardly likely that the wonderful powers of producing extreme cold, which have

resulted from the researches of Professor Dewar and others, can long be without many important applications to the Arts and Industries.

Captain Baden-Powell's paper on "Kites" showed the possible practical applications to military and surveying purposes of that which has always been considered but a child's toy; and from what he said there seems little doubt that, at all events for purposes of warfare, kites will take a useful place by the side of balloons for observation and signalling.

Mr. Clayton Beadle gave an interesting sketch of "The Recent History of Paper-making." Mr. Valentine, in his paper on "The Preparation of Meat Extracts," showed how much had been done in the condensation of nutritious material into a very condensed and portable form.

Mr. Edwin Sachs criticised the methods of modern "Stage Mechanism" in his paper on that subject, and while he showed what great advances had been made in scenic illusions, he also pointed out how in very many cases stage managers and theatrical architects had neglected to avail themselves of the resources of modern invention.

Mr. Brudenell Carter, in his paper on "Children's Sight," drew special attention to the work of the recent Departmental Committee on this subject, and urged the importance of proper provision being made in elementary and other children's schools for ensuring that too great a strain was not put upon the sight of the children. One point which came out clearly from Mr. Carter's paper, was that the children in elementary schools are far better off in this respect—as in other respects—than those in the oldest and wealthiest foundations.

Mr. Thomas Potter's paper on "The Fire-proof Construction of Domestic Buildings" gained special interest from the recent disastrous fire in the City. The principles he laid down were of considerable importance, and well deserve the attention of those who are responsible for the prevention of fires in cities.

Miss Clive Bayley suggested "The Revival of Hand-loom Weaving" as providing a suitable occupation for women, and gave an excellent account of the progress which had already been made in it. She pointed out what a large demand there was for hand-made fabrics, and how easy it would be to supply this demand by means of proper organisation.

Professor Vivian Lewes added one more to the useful papers which he has given the

Society on subjects connected with gas lighting, by his paper on "Water Gas and its Applications." He gave a very full account of the process of manufacturing water-gas and of the extent to which it is now used in substitution of coal-gas. One important point raised was the danger to life of using the newer illuminant. In Professor Lewes's opinion there was little if any more risk with water-gas than with coal-gas, and in this opinion he was confirmed by Mr. Corbet Woodall, who was in the chair.

II.—INDIAN SECTION.

At the opening meeting (January 20), Sir Mountstuart Grant Duff read an interesting and anecdotal paper, entitled "Recreations of an Indian Official," setting forth the cultivated pursuits that occupied the leisure moments of his rule in Madras, and pointing out "some of the things which one learns incidentally by living in India if only one makes a reasonable use of even very indifferent eyes." In a very able paper, Mr. Herbert M. Birdwood described, on February 17, the origin and progress of the Bombay plague, explaining the elaborate methods so energetically carried out by the local authorities to grapple with the calamity. From the position of one whose official duties had afforded special opportunities of tracing the influence of Sir Henry Maine's ideas, Mr. C. L. Tupper dealt, on March 10, with the Indian career of the distinguished author of "Ancient Law;" his suggestive paper being followed by a discussion of exceptional weight and authority. The earthquake that a year ago devastated the province of Assam, causing the loss of some 1,500 lives, was the subject of a graphic and exhaustive paper, read on March 31, by Mr. Henry Luttmann-Johnson, who was able to include in it much useful information not previously made public. On April 21, Mr. Horace Bell gave a comprehensive review of recent railway policy in India, and maintained that the time has come when State action in regard to railways should be limited to inspection and control. On April 28, an excellent and well-timed paper on "India and her Currency," was read by Sir Edward Sassoon. The session terminated on May 19 with a well-reasoned paper on "Colonies and Chartered Companies," by Sir Alfred Lyall, who contended that in the altered condition of the world, trading corporations are no longer "convenient agencies for the acquisition and administration of territory."

III.—FOREIGN AND COLONIAL SECTION.

Four meetings of this Section were held during the session. On January 18, Mr. Frederic Villiers read a paper descriptive of his recent journey from the Nile to Suakin, a route which had long been closed to Europeans and to trade owing to the Mahdist supremacy. On March 15, Mr. Nevile Lubbock read a paper on "The West Indies and the Sugar Bounties," in which he showed how adversely the staple industry of these colonies has been affected by the stringent protectionist policy of Germany and France, and suggested methods for counteracting it. On April 5, Mr. John Lowles, M.P., delivered an address on "The British Empire: its Resources and Future;" and on May 24, a paper by Mr. W. Hamilton Merritt was read, entitled "The Goldfields of British Columbia and the Klondyke." In it Mr. Merritt, while recording the output of gold in these districts up to the present time, laid stress upon the great possible developments in this industry in the future.

IV.—APPLIED ART SECTION.

Mr. J. Hungerford Pollen read a learned paper on "Renaissance Woodwork in England" at the first meeting of the Section on January 25th, in which he described from the architectural point of view the beautiful woodwork in the old mansions spread about the country. The subject was further illustrated by a fine series of lantern slides showing many of the halls with their grand panelling, screens, fireplaces, &c., which were lent by the Science and Art Department.

Mr. Cyril Davenport gave a full description of the various objects of "The English Regalia" in a paper read on February 22nd which was illustrated by lantern slides taken from photographs, and coloured by Mr. Davenport in a remarkable manner, so that the individual precious stones were seen in their natural colours.

At the third meeting Mr. Lewis Foreman Day read a valuable paper on "The Making of a Stained Glass Window," in which he set himself the task of showing how such windows could best be made. After dealing with the material, the treatment it undergoes, the design and the framework of lead, he came to the conclusion there was no mystery about the old glass, and that as good stained glass could be made to-day as the mediæval artist produced. In illustration of the paper, Mr. Day showed examples of old glass, and specimens of the

varied colours in modern glass, by projecting the image of the glass itself on the screen.

On March 29, Sir Edward Maunde Thompson, Principal Librarian of the British Museum, read an important paper on "English Art in Illuminated Manuscripts," which consisted of a masterly review of the history of the illuminated MSS. produced by Englishmen at a time when the pictorial art of the country was almost exclusively confined to this mode of treatment. The paper was illustrated by a series of lantern slides taken from some of the finest mediæval manuscripts in existence.

Mr. Joseph Pennell, in his paper on "Senefelder and the Centenary of Lithography, 1798-1898," read on May 3, pointed out that we have the inventor's own authority for the assertion that although experiments on printing from stone had been undertaken in 1796, chemical printing (or lithography as now practised) was not discovered until 1798. Mr. Pennell's paper was illustrated by a series of lantern slides taken from the masterpieces of the art in the Print-room of the British Museum.

The last meeting of the section was on May 10, when Mr. F. S. Ellis read an appreciative paper on "The Life Work of William Morris," in which the different productions of Morris's genius were reviewed. The meeting was held in the afternoon, and a fine collection of objects illustrating Morris's art was shown by daylight. There were two fine tapestries—one of the "Four Seasons," from Morris's own design, lent by the Science and Art Department, and the other a reproduction of Sandro Botticelli's "Primavera," lent by Messrs Morris and Company.

V.—CANTOR LECTURES.

Six courses of Cantor lectures were given during the Session. The first of these was by Dr. Eugene Obach on "Gutta Percha." Dr. Obach is a well-known authority on this subject and his position as chemist to the important firm of Messrs. Siemens Brothers has given him great experience of the application of gutta percha in telegraphic work, and for other purposes. His lectures formed an exhaustive monograph of the subject. It was desirable that the history should be written before all those who had been connected with the introduction of the material into the industry had passed away and been forgotten and the great mass of historical information which Dr. Obach has collected will certainly make this course of Cantor lectures the

standard work of reference for this subject. By the liberality of Messrs. Siemens Bros., who contributed a sum of £150 for the purpose, the Society was enabled to publish these lectures in a very complete form, and with much supplementary matter.

Later on in the session the kindred subject of "India-rubber" was treated in two lectures by Dr. Morris. In these lectures the sources of supply of the material were the subjects principally considered. Besides describing the well-known plants from which india-rubber is mainly obtained, Dr. Morris indicated several less known plants from which the gum can be procured, and also described improvements in the method of manufacture which will probably, to some extent, supersede the old-established and crude methods which were well described in the course of lectures by Mr. Thomas Bolas on the subject in 1880.

The second course of Cantor lectures was by Mr. Cyril Davenport on "Decorative Book-binding." The principal feature of this course was the manner in which it was illustrated by coloured lantern slides prepared by Mr. Davenport himself, mainly from originals in the British Museum. In connection with this course, there was arranged a small exhibition of bookbindings.

Mr. Hugh Stannus, to whom the Society is indebted for several interesting courses of lectures on the application of Art to industrial purposes, gave a course of four lectures in the early part of the present year on "The Principles of Design in Form."

These were followed by three lectures by Professor Noel Hartley on "The Thermo-Chemistry of the Bessemer Process." A melancholy interest is attached to these lectures, because while they were in actual course of delivery, the death occurred of the distinguished inventor whose work they were intended to commemorate. Professor Hartley has been for a long time engaged on the application of the spectroscope to the Bessemer flame, and this course of lectures included the results of his investigations.

The last course of lectures for the year was delivered by Professor Carus Wilson, late Professor of Electrical Engineering at the McGill University, Montreal, on "Electric Traction." The application of electric power to railways has formed a special object of study to Professor Carus Wilson for some time past, and his lectures embodied the results of considerable original investigation, and will, when published, be found to be of great value to

those engineers who are dealing with this rather new and difficult subject.

VI.—JUVENILE LECTURES.

The usual short course of Juvenile lectures was delivered during the Christmas holidays by Professor William Ramsay, the subject selected for the lectures being "Fire." Of the two lectures, the first was devoted to an explanation of the principles of combustion, while the subject of the second was the electric spark. Both lectures were very fully and beautifully illustrated by a fine series of experiments.

VII.—ALBERT MEDAL.

The Albert Medal for this year has been awarded to his Excellency Dr. Robert Bunsen, the veteran professor of chemistry at the University of Heidelberg. Amongst the numerous and important scientific discoveries which have rendered the name of Bunsen famous wherever science is valued, perhaps the most striking is the one in which he was associated with his distinguished colleague, Professor Kirchhoff, viz., spectrum analysis, a discovery which has shed a new and unexpected light on the composition of terrestrial matter, and has enabled us to obtain a distinct knowledge of the chemical composition of sun and stars. The contributions which Bunsen has made in the application of chemistry and physics to the arts and manufactures are of the utmost value, and their importance may be measured by two out of many instances. The Bunsen battery was, until the introduction of the dynamo, the cheapest source of electricity; the Bunsen gas burner, by which a non-luminous, smokeless, but highly heated flame is obtained, is now not only indispensable in all laboratory work, but is used for heating purposes in thousands of houses and manufactories, and for illumination, by the incandescent system, in millions of lamps. Beyond these Bunsen's contributions to the sciences of chemistry and physics have been of the highest importance; but, perhaps, the greatest benefit which he has conferred through a long life devoted to the advancement of science, has been the influence which he has exerted as a teacher.

VIII.—MEDALS.

The Council have awarded the Society's Silver Medal to the following readers of Papers during the Session 1897-98.

At the Ordinary Meetings :—

To PROF. JAMES DOUGLAS, for his paper on the "Progress of Metallurgy and Metal Mining in America during the last Half Century."

To SAMUEL RIDEAL, D.Sc., for his paper on "The Purification of Sewage by Bacteria."

To CAPTAIN B. F. S. BADEN POWELL, for his paper on "Kites: their Theory and Practice."

To PROF. J. A. EWING, F.R.S., for his paper on "Linde's Method of Producing Extreme Cold and Liquefying Air."

To PROF. SILVANUS P. THOMPSON, F.R.S., for his paper on "Telegraphy Across Space."

To MISS CLIVE-BAYLEY, for her paper on "The Revival of Hand-loom Weaving."

To J. K. STARLEY, for his paper on "The Evolution of the Cycle."

In the Indian Section :—

To HERBERT MILLS BIRDWOOD, C.S.I., M.A., LL.D., for his paper on "The Plague in Bombay."

To HENRY LUTTMAN-JOHNSON, I.C.S., for his paper on "The Earthquake in Assam."

To SIR ALFRED COMYNS LYALL, G.C.I.E., K.C.B., D.C.L., for his paper on "Chartered Companies and Colonisation."

In the Foreign and Colonial Section :—

To NEVILLE LUBBOCK, for his paper on "The West Indies and Sugar Bounties."

In the Applied Art Section :—

To J. HUNGERFORD POLLEN, for his paper on "Renaissance Woodwork in England."

To SIR E. MAUNDE THOMPSON, K.C.B., for his paper on "English Art in Illuminated MSS."

The thanks of the Council were also voted to the following members of the Council :—

To R. BRUDENELL CARTER, F.R.C.S., for his paper on "Children's Sight."

To CAPTAIN W. DE W. ABNEY, C.B., F.R.S., for his paper on "Photography and Colour Printing."

To LEWIS FOREMAN DAY, for his paper on "The Making of a Stained Glass Window."

IX.—OWEN JONES PRIZES.

These prizes have now been awarded annually since the year 1878. The Council of the Society of Arts are trustees of the sum of £400, presented to them by the Owen Jones Memorial Committee, being the balance of subscriptions to the memorial fund, upon condition of their expending the interest thereof in prizes to "Students of the Schools of Art who, in actual competition, produce the best designs for Household Furniture, Carpets, Wall-papers and Hangings, Damask, Chintzes, &c., regulated by the principles laid down by Owen Jones." The prizes are awarded on the

results of the annual competition of the Science and Art Department.

Six prizes were awarded this Session, each prize consisting of a bound copy of Owen Jones's "Principles of Design," and a Bronze Medal.

The list of the successful candidates was given in the *Journal*.*

The next award will be made this summer on the result of the present year's examinations. Six prizes have again been offered for competition.

X.—STOCK PRIZE.

In 1871 John Stock left £100 Consols to the Society, with the condition that the interest should be applied for the promotion of drawing, sculpture, and architecture. From time to time, as the accumulated funds permitted prizes have been awarded under this head, the last previous award having been made in 1893. A Gold Medal, or a prize of £20, was offered for competition among the students of the Schools of Art at the annual competition of 1897, for "the best original design for an architectural decoration suitable for the interior of a building."

At the request of the Council, the adjudication was made by the examiners of the Science and Art Department, who awarded the prize to Alfred Cumber, of the Goldsmiths' Institute, New-cross.†

XI.—PRIZES FOR DRAWING.

Since 1889, the Council have placed at the disposal of the Royal Drawing Society, for competition among the candidates at its annual examination, 12 Bronze Medals, and, as usual, these medals were awarded for drawings sent in by students to the exhibition held by the Drawing Society in April last.

XII.—EXAMINATIONS.

The considerable growth in the number of candidates entering for the Society's Examinations still continues, the number for this year being 7,636, an increase of 717 over last year's number of 6,919. The figures for the past nine years are given in the following Table, from which it will be seen that the numbers are now more than three times as great as in the year 1890, and that they have more than doubled in the past six years :—

* See *Journal*, August 27, 1897, vol. xlv., p. 1027.

† See *Journal*, October 29, 1897, vol. xlv., p. 1163.

Year.	No. of Candidates.	No. of Papers worked.	No. of Centres.	No. of Sub-jects.
1890.....	2,315	2,474	79	14
1891.....	2,460	2,667	78	14
1892.....	*2,928	3,143	96	13
1893.....	3,702	3,916	109	13
1894.....	4,106	4,376	131	14
1895.....	4,777	5,108	146	14
1896.....	6,111	6,568	197	16
1897.....	6,919	7,513	221	19
1898.....	7,636	8,372	243	19

* Total, with supplementary autumn examination, 3,351.

It would be satisfactory if it could also be stated that the candidates generally keep up to the same standard, but this is certainly not the case. There is probably not a very serious difference, but the tendency of recent years has been for the qualifications of candidates to decline, and the average of those entering is distinctly below the average of those who entered a few years ago. The per-centage of first-class certificates in 1896 was 10·5, in 1897 it was 8·8, in the present year it is 6·05. The per-centage of failures has not altered so regularly. From 1895 to 1897 the per-centage of failures decreased from 21 to 19·8, which was a satisfactory sign. For the present year the per-centage of failure has increased, and is now 26·1. It must not be understood from this that the better class of candidates are of a lower standard than of old, or that there are fewer of them. This is distinctly not so. There appears on the whole to be a slight improvement at the top of the list, not perhaps as regards the quality of the very best candidates, which is not likely to improve, but as regards the numbers of high-class candidates. In working out the average results, however, this slight improvement is entirely counterbalanced by the fact that the large increase of candidates is due in the main to the addition of students of a less educated class.

The rapid increase in numbers is due, as has been previously pointed out, to the fact that the County Councils are now able to dispose of considerable funds for the promotion of technical education, and this, as defined by the Technical Education Act, includes the commercial subjects in which the Society holds examinations. Large numbers of students are encouraged to enter for the examinations, and in many cases have their fees paid for them. The result of this is that while the numbers go up, the standard goes

down. It is not to be argued that this is wholly a bad sign. The Society's Examinations serve two distinct purposes. They are on the one hand a test of capacity, and they afford students who have passed them evidence that they are qualified in subjects which may be of service to them in their future careers. But the examinations also serve another purpose. The hope of obtaining a certificate may often act as an inducement to students to study a subject, and though the certificate itself may be of slight value, or even though the students may fail to get a certificate at all, they will have profited by the actual study. It does not, therefore, seem desirable to the Council that because the numbers increase the standard should, *pari passu*, be raised. If the standard were made too high, the Examinations would no longer be an attraction to the humbler class of students, while it is obvious that if the standard was appreciably lowered, the examinations would fail to have any value whatever. Practically, therefore, the standard for each class has been kept at about as nearly as possible the same level as that which the experience of past years proves to be most practically useful, probably, if anything, it has a tendency to rise rather than to fall. But since a large number of less-qualified students enter for the examinations, the proportion of those taking first-class must, of necessity, if the standard is kept up, be smaller, while the numbers of those who fail to pass at all is likely to increase; but not to increase in anything like the same degree as the proportion of first-classes decreases. It may reasonably be anticipated that as the excellent work of the County Councils goes on and produces its natural results, the class of new students who have been brought under examination will be improved, and that the proportion of first-classes will again rise to the former level.

The increase in numbers has been spread over nearly the whole range of the examinations. There has been a falling off in the two musical subjects—for Rudiments of Music 366 entered, against 402 last year, a decrease of 36; and for Harmony 161, against 190, a decrease of 29. In all the other subjects—that is to say, in all the commercial or technical subjects—there has been practically an increase, or at all events no falling off. In Précis-writing there is one candidate less than last year—17 against 18. In French also there were 5 fewer, there being 322 against 327, but this deficiency is more than made up for by the increase in Elementary French, a subject introduced last

year; for this there were 218 candidates, last year there were 191. The total number in French and Elementary French together amounts to 540, an increase on the corresponding number last year (518) of 22. German shows an increase of 16, 227 against 211; Elementary German an increase of 49, 110 against 61. Italian shows a small, but a good, proportionate increase of 12; 37 compared with 25 last year. In Spanish there are 92 compared with 85, and in Elementary Spanish, 41 against 22. Portuguese also shows an increase, 26 against 14. The regular increase in all these modern-language subjects is certainly a satisfactory feature. It is also satisfactory to note that there is a distinct advance in Arithmetic, 259, whereas last year there were only 191, an increase of 68. This is a subject which ought to draw larger numbers. Possibly the reason that it does not do so is that there are many other examinations available in it. Arithmetic also suffers from the drawback that it is not scheduled by the Science and Art Department as a technical subject. The same remark is applicable to English, in which also a moderate increase is to be noted: there are 189 candidates this year, an increase of 14 over the 175 last year. Commercial Geography also shows an increase from 62 to 120; this is, comparatively, a large addition. The subject of Economics has not attracted very many more than last year—there are now 27, there were then 23. The two subjects which, as usual attracted much the largest numbers are Book-keeping and Shorthand. Book-keeping shows a large increase—there were 3,730 candidates, an addition of 295 on the 3,435 of last year. In Shorthand there was an increase of 232—the numbers being 1,791 and 1,559. It is a matter of regret that no candidates ever enter for the less popular languages—Russian, Danish, Japanese, and Chinese—and this fact is a comment upon the absence of facilities in this country, as compared with those in other countries, for education in modern languages. In Domestic Economy there were 21 more than last year, the numbers being 206 and 185.

The examiner in Arithmetic notes the usual contrast between the excellent work of the medallists, and the inaccurate and trivial performances of the worst of those who failed, there being all intermediate varieties. The work of the best candidates is of a very high class; the work of the worst it must be confessed of a very low one. Besides the two medallists, only two other candidates did well

enough to obtain a place in the first-class; 32 took seconds—all of these did fairly well; 87 others attained or exceeded the minimum required for a pass. In this subject, the increase in numbers seems, on the whole, to have been accompanied by an improvement in the work.

The examiner in English remarks that though there are as usual too many slovenly and inaccurate papers, which cannot properly be allowed to pass, the present year yields a creditable average of fairly intelligent candidates who have mastered the rudiments of English grammar, and have learned how to apply those rules in the art of English composition; 23 first-class certificates were awarded, 50 second, and 76 third.

In the subject of Book-keeping, the examinations suffered a severe loss by the death of Mr. J. O. Chadwick, who had acted as examiner in that subject since the year 1883. In that year only 141 candidates were examined, a number which gradually mounted up year by year to 3,435 in 1897, an increase which it cannot be doubted was, to a large extent, due to the character of the examination as modified by Mr. Chadwick, and to the manner in which it was carried out by him as well as to the fact of the creation of book-keeping classes by County Councils in connection with the Technical Education Grant. The Society, however, were fortunate enough to secure a most efficient successor in the person of Mr. G. Walter Knox, B.Sc., F.C.A., ex-president and chairman of the examination committee of the Institute of Chartered Accountants in England and Wales. Mr. Knox, who is a member of the firm of Knox, Burbidge, Cropper and Co., expressed a wish that his partner, Mr. L. Cuthbert Cropper, F.C.A., should be associated with him as assistant-examiner, and this arrangement was willingly acceded to by the Council. As the syllabus for this year's examination had been prepared and issued under Mr. Chadwick's supervision, Mr. Knox undertook to follow as far as possible upon the lines laid down by him, and the paper set was in accordance with the syllabus published for 1898. The paper, however, was a little shorter than those usually set of recent years, which were somewhat long for an average student to do in the time allowed. All reference to shillings and pence—as a matter of arithmetic—was also omitted. The paper, on the whole, was easier, but the results have not been so good. The actual numbers were as follows:—Of 3,730 papers, 120 were given first-class certi-

ificates, 861 second, and 1,938 third, 811 failing to pass at all. These figures work out into per-centages as follows:—First, 3·21; second, 23·1; third, 51·95; failed, 21·74. The corresponding per-centages for 1897 were:—First-class, 9·14; second, 38·14; third, 43·29; failed, 9·43. As the per-centages in previous years had been steadily falling, they would certainly in any case have been lower this year than last; but in addition to this the system of marking adopted was doubtless a little more severe.

The examiner in Shorthand notes that there are again too many candidates whom he has been reluctantly compelled to place in the category of “not passed,” the failures having arisen less from a deficiency in point of speed than from “a want of accuracy in transcription, combined with bad spelling, wretched punctuation, and clumsy penmanship.” The first and second classes show considerable skill and indicate careful training, and the third-class papers that the examiner was able to pass were, on the whole, well worked. The number of papers worked was 1,791: 68 first-class, 349 second, and 762 third-class certificates were awarded, while 612 failed to pass.

In the examination in Commercial Geography, the examiner states that the unusually large number who came forward acquitted themselves better than at any previous examination, though he regrets that he was not justified in awarding a large number of first-class certificates. Throughout the whole of the work there was a conspicuous absence of foolish blunders, and in most cases marks were lost on account of the papers being incomplete rather than from erroneous answers. Seven first-class certificates were awarded, 58 second, and 37 third; 18 were not passed.

The examiner in Type-writing regrets the large number of failures—148 out of 433 entries—and hopes that teachers will turn their attention to the importance of a good general education, so that their pupils may take the examination with some prospect of success, instead of relying, as happens in too many cases, on mere manipulative dexterity. The first and second-class work was very fair; but in a large proportion of the failures the papers were extremely bad. There were 60 first-class certificates, 58 second, and 167 third.

In Economics the examiner notes a considerable improvement in the papers this year, as compared with those of last year. But the improvement is almost entirely in the knowledge of economic theory shown by the candidates, while ignorance of the bare outlines of English

economic history is a remarkable characteristic of most of the papers.

The examiner in Précis-writing notes that there is some improvement this year, but to judge from his remarks, the work of many of the candidates leaves a good deal to be desired.

The examiner in French speaks in the highest terms of the character of the papers sent in, which, he thinks, show marked progress. Last year, out of 327 candidates, the examiner was able to grant 236 certificates, returning 91, or a trifle over 27 per cent., as “not passed.” This year, out of 322, he is able to give 259 certificates, leaving only 63 “not passed,” or somewhat less than 20 per cent. With regard to the elementary examination, the proportion of candidates admitted to pass is still very fair, although it does not quite reach the high standard of last year. Of the 218 who entered, 116 passed and 102 failed—most of these latter the examiner considers would have passed with a little more preparation.

The examiner in German notes together with a considerable increase in the number of candidates an improvement in the results, as compared with last year. Of the 337 candidates who entered in the two divisions in German, there were, altogether, only 24 failures, of whom 9 were in the Elementary. The work of the best candidates was excellent. The general work of the candidates for Elementary German was also extremely good.

The work of the candidates who presented themselves for examination in Italian has quite satisfied the examiner, though he notes a good many mistakes in the rendering of commercial and technical terms, both in English and Italian. Out of the 37 candidates who entered, 10 failed, 9 were awarded a first-class certificate, 13 a second, and 5 a third.

The examiner considers the result of the examination in Spanish as very satisfactory—three-fifths of the candidates obtained over 50 per cent. of the marks. The accuracy of the commercial expressions employed was exceptionally creditable. The Elementary paper was also very well worked. Of the 41 candidates who presented themselves, only 6 failed.

The examiner in Portuguese was able to award certificates to all the candidates who entered—16 first, 6 second, and 4 third. The technical portion of the paper was the weakest point, though this was done in an intelligible manner by the better candidates.

The papers in Domestic Economy are stated by the examiner to be much superior to those

of any previous year. Out of 206 entries, only six failed. A great majority were awarded second-class certificates (110); there were 30 first, and 60 third. The examiner notes that the general teaching of the subject must be much fuller, and more efficient than formerly, and the demand for instruction much greater.

With regard to the musical subjects, the examiner considers that the general result was good. As previously remarked, the numbers in these subjects have fallen off, but the character of the paper seems to be quite up to that of previous years. In Rudiments of Music, 116 Higher certificates were awarded, and 119 Elementary certificates, while 131 failed. In Harmony there were 44 Higher and 71 Elementary certificates, while 46 failed.

Judging from the opinions expressed by the examiners, it would seem that the general standard of the examinations is about up to that of previous years, although the proportion of well-taught candidates is somewhat less, and the proportion of third-class and failures more, than in the years when a smaller number entered themselves for examination.

The Council have, as in previous years, to acknowledge the assistance they have received from many of the City Companies. The Clothworkers offered special prizes for certain of the language subjects, and the following Companies subscribed to the special Prize Fund, out of which money prizes are provided for others of the subjects*:—Goldsmiths, Merchant Taylors, Skinners, Leathersellers, and Salters.

XIII.—PRACTICAL EXAMINATIONS IN MUSIC, 1897.

The practical examinations in Music for 1897 were not concluded until the 10th July, too late for the results to be included in the last Report of the Council.

The system of examination adopted in the previous year was continued without alteration. Candidates are asked to select for themselves which of four standards they choose to be examined in. Standard I. is easy, Standard II. moderately difficult, Standard III. difficult, and Standard IV. very difficult. For each standard a list of music is given, and a selection from this list is sent to the candidates six weeks previous to the examination. Candidates are expected to play or sing pieces from

the selected list, as well as to play or sing a piece, or a portion of a piece, at sight.

In all 392 candidates entered, 13 of these took up two subjects, so that there were 405 examinations. Of these there were 361 passes and 44 failures. The following were the subjects taken up:—Piano, singing, violin, viola, mandolin, clarinet, and organ. 284 entered for the piano, of whom 257 passed and 1 obtained a medal; 54 entered for the violin, of whom 49 passed and 2 obtained medals; 2 entered for the viola, both passed and 1 took a medal; 1 took a medal for the mandolin; 1 entered and passed for the organ; 60 entered for singing and 51 passed, 9 obtaining medals; 1 entered for the clarinet, but failed.

Mr. John Farmer, of Balliol College, Oxford, and Director of the Harrow Music School, acted as Examiner, Mr. Ernest Walker, M.A., Mus. Bac. Oxon., and Mr. Burnham Horner, as Assistant-Examiners.

XIV.—PRACTICAL EXAMINATIONS IN MUSIC, 1898.

The Practical Examinations for the present year have not yet been concluded. They commenced on the 27th June, and will be finished on or about the 13th July, after which a summary of the results will be given in the *Journal*. No alterations have been made in the system adopted in 1896, and continued last year, and to judge from the increasing numbers of candidates, the present system appears to meet the requirements of the classes for whom it is intended. In 1896, the first year in which the new system was tried there were 376 candidates, in 1897 there were 392, and for the present year 558 have entered. So considerable an increase is satisfactory, as testifying to the appreciation in which the examination is held, but the difficulty of holding so large a number of individual examinations is considerable, and the Council will have to consider whether it may not be desirable to limit the numbers, either by raising the standard or by some other means.

XV.—COMMITTEE ON THE DETERIORATION OF PAPER.

For some time past the statement has been current that the paper on which modern books are printed, and modern documents written, is of a far more perishable nature than that used in older times; and it has not infrequently been suggested that the materials of which modern paper is made are such that in a comparatively short time the paper

* The Clothworkers' Company Prizes are offered in Italian, Spanish, and Portuguese; the other prizes in English, Commercial Geography, French, and German.

itself may be expected to disintegrate, with the result of the disappearance of all works which had been printed at a date later than about the middle of the present century.

In June, 1897, the Council appointed a Committee* to look into this matter, and report upon it. This Committee took a good deal of evidence on the subject. They addressed a circular to librarians, paper-makers, and others interested in the matter, asking for information, and they made a special application to librarians, asking for examples of books which had already begun to show signs of perishing. They soon came to the conclusion that though there was, as is well known, a large amount of inferior paper now manufactured, and sometimes used for publications and books of permanent value, the danger had been over estimated. Some cases of actual disintegration of paper were submitted to the Committee, but such cases were not very numerous. They were found in modern papers of all grades, and in books, which had for the most part been subjected to ordinary conditions of storage and use. The results of the Committee's examination of these specimens, and the conclusions to which they came are set out in the Report† which was published in the *Journal* in May last.

In the Report the Committee also suggested a normal standard of quality for papers required for publications of permanent value. Such papers they consider ought to contain not less than 70 per cent. of rag fibre, the sizing should contain not more than 2 per cent. of rosin, and the total mineral matter (ash) should not be more than 10 per cent.

The Committee have also reproduced in abstract form the official publications bearing on the subject of paper issued by the German Imperial Testing Station. These will be issued as an Appendix to the reprint of the Report, and the Appendix will also contain a *précis* of the information and suggestions submitted to the Committee by their correspondents.

XVI.—EXHIBITION OF ACETYLENE GAS GENERATORS.

The Imperial Institute, at the request of the Acetylene Illuminating Company of London and Foyers, manufacturers of carbide of calcium, having decided to hold an Exhibition of Acetylene Gas Apparatus at the

Institute, an application was made to the Council of the Society of Arts to appoint a Committee to test the apparatus intended for the Exhibition. The object of this was to ensure that no apparatus should be admitted unless it was shown to fulfil the requisite conditions of safety. At present there is no special legislation for apparatus in which gas is generated from calcium carbide, although an Order in Council has been issued regulating the use of carbide and of the acetylene gas obtained from it. While there may be no doubt that the majority of the generators now in the market are safe, with ordinary precautions, generators might be so constructed as to be a source of serious danger, especially in the hands of unskilled labour. It was, therefore, considered essential that any apparatus shown to the public at the Exhibition should, at all events, be shown to be reasonably safe, and the object of appointing the Committee was that the public might have this guarantee with regard to the apparatus tested by them. It must be distinctly understood that the Committee have not pronounced any opinion as to the merits of any apparatus.

The Committee met for the first time in April last, and laid down a set of conditions which every apparatus tested was required to fulfil. The London County Council, through the good offices of Mr. Alfred Spencer, the Chief Officer of the Public Control Department, were kind enough to place at their disposal, as a testing station, the premises belonging to the County Council at 211, Harrow-road, now used as the Weights and Measures Office. The accommodation provided proved entirely suitable and very convenient, and every facility was afforded by Mr. Pemberton Stubbs, acting under Mr. Spencer, both to the Committee and to the exhibitors of apparatus. Each apparatus sent to the testing station underwent a special series of tests, carried out under the authority and supervision of the Committee, by Mr. W. N. Duffield, of the City of London Gas Testing Station. Twenty-six apparatuses were found to fulfil the required conditions, and were admitted to the Exhibition.

The Committee feel that they are specially indebted to two of their members—Professor Vivian B. Lewes and Mr. Boverton Redwood—who took an active part in the work, and whose special experience was of the greatest value to the Committee in their deliberations. The Exhibition itself was opened on the 15th of this month by Sir Owen Tudor Burne, G.C.I.E., Chairman of the Council of the

* The names of the Committee are given in the *Journal* for September 3, 1897, vol. xlv., p. 1055.

† *Journal*, May 20th, 1898, vol. xlvii., p. 597.

Society of Arts, and it is proposed that it should remain open, at any rate, until the end of August.

XVII.—INTERNATIONAL CONGRESS ON TECHNICAL EDUCATION.

The Report of the proceedings of the International Congress on Technical Education, which was held under the auspices of the Society in June, 1897, was published in November. It contains the papers read and the discussions, with appendices giving lists of officials, delegates, and others taking part in the Congress. The Report was issued to all those who had become members of the Congress, and was also sent out largely to public libraries and institutions in this country and abroad.

The total cost of the holding of the Congress amounted to £617 13s. 2d. This was met by contributions from nine of the City companies—the Mercers, Drapers, Fishmongers, Goldsmiths, Merchant Taylors, Clothworkers, Vintners, Leathersellers, and Carpenters, by subscriptions from members of the Congress, who paid 5s. each, and by the sale of the Report. The total receipts from all these heads were £625 7s. 9d. There were also other charges, the principal of which was the cost of the publication of the proceedings of the Congress in the *Journal*, which were not charged to the Congress itself, but to the general expenses of the Society.

XVIII.—MEMORIAL TABLETS.

The tablet has been set up, which, as stated in the Report of last year, the Council had decided to place on the house at Hampstead, known as Belmont, Rosslyn-hill, which was formerly the residence of Sir Harry Vane. The Council have also determined to erect a tablet on No. 50, Wimpole-street, where Mrs. Elizabeth Barrett Browning, wife of Robert Browning, the poet, lived for some time, and from which house she was married.*

XIX.—PARIS EXHIBITION, 1900.

When the Royal Commission for the Paris Exhibition of 1900 was gazetted in November last, the Chairman of the Council, Sir Owen Tudor Burne, was appointed a member of the Commission as a representative of the Society of Arts.

* A complete list of the tablets which had been previously set up will be found in the Report of the Council for 1895-1896. *Journal*, June 26, 1896, vol. xliv., p. 681.

XX.—CONVERSAZIONE.

The annual Conversazione of the Society was held this year at the Natural History Museum, by permission of the Trustees of the British Museum, to whom the Council are much indebted. This is the second time on which the building was placed at the disposal of the Society for the purpose, the first occasion having been in 1890.

As the Museum is not intended to be opened in the evening, it is not sufficiently lighted for the purposes of a Conversazione, consequently special arrangements have to be made for its illumination, and for this reason only a small portion of the building can be utilised. On the present occasion the only parts of the Museum used were the Central Hall, with its surrounding corridors and galleries, and the Bird Gallery, which occupies a portion of the ground floor of the western wing of the Museum. These galleries were specially lighted with the electric light, the expenses of the installation being shared with the Royal Geographical Society, the Royal Colonial Institute, and the Institution of Electrical Engineers—all of which Societies held *Conversazioni* in the building about the same date.

The usual arrangements for music and refreshments were made. Tickets were issued as on previous occasions to the members of the Society, and additional tickets were sold to members at the price of five shillings each. The Metropolitan District Railway Company were good enough to allow visitors who used the underground railway the free use of their subway leading from the South Kensington railway station into the grounds of the Museum. The total number of visitors attending the *conversazione* was 1,679.

The Council desire to express their indebtedness to the principal officers of the Museum for the great assistance they rendered in carrying out the arrangements for the evening. But for the personal care and attention given by certain of them the *Conversazione* could not have been made the success it was.

XXI.—NEW COUNCIL.

The usual balloting list is submitted, in accordance with the Bye-laws, for the election of new members of Council. On the list of Vice-Presidents there are five new names—Sir Owen Tudor Burne, Lord Belhaven and Stenton (both of whom were on the last Council as ordinary members of Council), Sir John Evans,

Sir Charles Malcolm Kennedy, and Sir Thomas Sutherland; none of these three last-named gentlemen held office last year. Sir Charles Kennedy was on the Council from 1889 to 1896; Sir John Evans and Sir Thomas Sutherland have not been on the Council in any capacity before. These gentlemen are proposed to take the places of the following retiring Vice-Presidents:—Sir William Anderson, Sir Courtenay Boyle, the Lord Chancellor, Mr. W. H. Preece, and the Earl of Rosebery.

As ordinary members of Council, the following are proposed:—Sir John Wolfe-Barry, Sir Walter Prideaux, Sir George Chubb, and Earl Grey. Of these, Sir Walter Prideaux and Lord Grey have not before served on the Council. Sir John Wolfe-Barry served from 1894 to 1896, and Sir George Chubb in 1890 and from 1893 to 1895.

XXII.—OBITUARY.

During the past year the Society has lost by death an unusual number of those who were closely associated with its work, and held office on its Council—no less than seven past Vice-Presidents or Members of Council having died since the annual meeting of last year. Mr. James Heywood had been a member for nearly forty years at the time of his death, and was on the Council twenty years ago. Sir Rutherford Alcock was a Vice-President for three years, and an active member of the Committee of the Indian Section. It may be interesting to note here a fact which was not recalled in the obituary notice in the *Journal*, that as a young man—in 1825 and 1826—Sir Rutherford Alcock obtained prizes from the Society of Arts for anatomical models. Sir Henry Doulton was one of the oldest members of the Society of Arts, his membership covering a period of 46 years. From 1877 he served constantly on the Council, and was, as members of the Society are well aware, one of its Albert Medallists. Sir Henry Bessemer, also one of those who received the Albert Medal, was connected with the Society even longer than Sir Henry Doulton, he having joined it in 1850. He became a member of the Council as far back as 1872, the year in which the Albert Medal was awarded to him. Sir Polydore de Keyser was a Vice-President from 1888 to 1889, at the time when, as Lord Mayor, he took an active part in the organisation of the British Section at the last Paris Exhibition. Mr. T. R. Tufnell was Treasurer of the Society in 1872, and afterwards a member of the Council. He took a great interest in the Society's work

about that time, and was a constant attendant at its meetings. Sir Robert Rawlinson was a member of the Society of forty-two years' standing, and from 1872 to 1892 he served in various capacities on the Council. He was a regular attendant at the meetings, and a frequent speaker.

In addition to the above, who all had seats on the governing body of the Society, the following should also be mentioned:—Mr. George Palmer, the head of the well-known firm of Huntley and Palmer, was a member of long standing. Mr. P. L. Simmonds probably contributed more to the proceedings of the Society than any other member, and was intimately associated with much of its work since he became a member in 1853. Mr. J. J. Holtzapffel's family's connections with the Society date back to the early part of the present century—his grandfather, his father, and he himself were all members of the Society, and his father was chairman of the Committee of Mechanics. He himself received the Society's silver medal for the paper he read in 1895. Mr. J. O. Chadwick was the Society's auditor since 1875, and its examiner in book-keeping since 1883. Mr. Ernest Hart gave the Society two excellent courses of Cantor lectures on "Japanese Art and Industries," and also on two occasions read papers before the Society. Sir Richard Quain, the eminent physician, was a member of the Society of Arts of forty years' standing.

Obituary notices of all the above have appeared in the columns of the Society's *Journal*.

XXIII.—FINANCE.

The annual statement of receipts and expenditure was published—in accordance with the usual practice—in the *Journal* last week. It shows the revenue and expenditure for the financial year ending May 31st last, the Assets and Liabilities of the Society, its Investments and the Trusts standing in its name.

One or two points may require a little explanation. The rent of the Society's house has been raised from £200 to £600. The original lease granted in 1775, was renewed in 1867, for 30 years, a premium of £2,250 having been paid on its renewal. When it expired in 1897, it was renewed for seven years, terminating in 1904, at the increased rent, no premium being charged. It was not found possible to obtain a renewal for a more extended period. The cost of the International Congress on Technical Education is shown as

£592, while the donations and other receipts amount only to £478 2s. This is explained by the fact that certain donations had been received during the financial year ending May, 1897, and were brought to account in the financial statement for that year. The amount received for advertisements in the *Journal* is much less than usual. This is to be accounted for by the fact that a new arrangement for the business of the advertisements has been made, under which Messrs. Street Brothers have undertaken the agency of the business. The arrangement with Messrs. Street was that they were to render accounts quarterly for the amounts collected in the previous quarter, and consequently there were no receipts from them in the first six months in the financial year. The receipts from the examinations show an excess over the expenditure, but there still remain certain charges for the examinations of 1898 which come into the financial year ending May, 1899.

The place of the late Mr. J. O. Chadwick, who had acted as the Society's auditor since 1875, has been taken by his son, Mr. Andrew D. Chadwick.

The CHAIRMAN moved the adoption of the Report, and said he thought the members would agree with him that the papers and lectures this year had been of a very high level. With respect to the examinations, he thought the Council were quite right in not raising the standard, in consequence of the larger number of less-qualified candidates who were coming forward. He might briefly refer to the three important committees which had been appointed this year. The Committee on the Deterioration of Paper had found that the paper in use at the present time was not quite so bad as they had been led to suppose it was, and he thought the Society had done good service in giving the information contained in the committee's report to the public. The Committee on Acetylene Generators had also done useful work in very carefully testing the machines now being exhibited at the Imperial Institute, and he was glad that the Society should have had some hand in seeing to the proper testing of the machines and in helping to support the new industry. The other committee now sitting was the committee appointed to organise an exhibition to commemorate the centenary of the invention of lithography, which will probably be held in October next, and will be of great interest in the history of reproductive art. A committee of the Council has also been appointed to consider the question of the Society's lease.

Mr. MARTIN WOOD, in seconding the adoption of the Report, said he thought the members were to be

congratulated on the great value of the papers which had been read, and the lectures delivered during the year. He was sorry that question of internal locomotion had been overlooked, and he should like to see the subject of inland water carriage treated at some of the meetings. The Society held a conference on the subject in 1888, and he thought the time had come when fresh attention might be directed to it. He was glad to see the numbers entering for the examinations increasing, because he felt it was a great advantage for the Society to connect itself with the provinces in this way. It was satisfactory that the Paper Committee had found that the evils of deterioration were not so universal as at first appeared, and he was glad the Committee had adopted a standard which no doubt the papermakers would adhere to, and purchasers insist upon. He should like to see steps taken to render the contents of the *Journal* better known. He inquired whether there was any reserve fund which could be applied for the purpose of building a house for the Society, in view of the expiration of the lease in 1904, and also asked if drawing could not be included in the curriculum of the Society's examinations.

Mr. ARTHUR BARCLAY asked if the conditions under which the acetylene generators at the Imperial Institute were tested would be published, as he thought the information would be useful.

The CHAIRMAN said the Committee were still carrying on tests on the working of the apparatus, and that when these were concluded a report would be published in the *Journal*. In reference to what Mr. Martin Wood had said about the inclusion of drawing in the examinations, the Society years ago used to hold examinations in drawing, but the Science and Art Department having added the subject to their examinations it became unnecessary for the Society to continue them.

Mr. FRANCIS COBB, in referring to Mr. Martin Wood's question as to the renewal of the lease or the acquisition of new premises, stated that for some years past the life compositions received from members had been specially invested to form a fund for that purpose.

The adoption of the report was then agreed to.

The CHAIRMAN moved a vote of thanks to Sir Henry Trueman Wood, who had so long and ably filled the office of Secretary, also to Mr. Wheatley, Mr. Room, and the other officers of the Society, which was carried unanimously.

The ballot having remained open for one hour, and the Scrutineers having reported, the CHAIRMAN declared that the following had been elected to fill the several offices. The

names in *italics* are those of members who have not, during the past year, filled the office to which they have been elected.

PRESIDENT.

H.R.H. the Prince of Wales, K.G.

VICE-PRESIDENTS.

H.R.H. the Duke of Saxe-Coburg and Gotha, K.G.	R. Brudenell Carter, F.R.C.S.
H.R.H. the Duke of York, K.G.	Right Hon. Viscount Cross, G.C.B.
Sir Frederick Abel, Bart., K.C.B., D.C.L., D.Sc., F.R.S.	Right Hon. George N. Curzon, M.P.
Duke of Abercorn, K.G., C.B.	Major-General Sir John F. D. Donnelly, K.C.B.
Captain W. de W. Abney, C.B., F.R.S.	<i>Sir John Evans, K.C.B., F.R.S.</i>
The Attorney-General, G.C.M.G., Q.C., M.P.	Hon. Sir Charles W. Fremantle, K.C.B.
<i>Lord Belhaven and Stenton.</i>	Sir Douglas Galton, K.C.B., D.C.L., F.R.S.
Sir George Birdwood, K.C.I.E., C.S.I., LL.D., M.D.	<i>Sir Charles Malcolm Kennedy, K.C.M.G., C.B.</i>
Sir Edward Birkbeck, Bart.	Sir Villiers Lister, K.C.M.G.
Sir Frederick Bramwell, Bart., D.C.L., F.R.S.	Prof. William Chandler Roberts-Austen, C.B., F.R.S.
<i>Major-General Sir Owen Tudor Burne, G.C.I.E., K.C.S.I.</i>	Lord Strathcona & Mount Royal, G.C.M.G., LL.D.
	<i>Sir Thomas Sutherland, G.C.M.G., M.P.</i>

ORDINARY MEMBERS OF COUNCIL.

Sir Steuart Colvin Bayley, K.C.S.I., C.I.E.	James Sewell Neville.
Michael Carteighe.	<i>Sir Walter S. Prideaux.</i>
<i>Sir George Hayter Chubb.</i>	William Luson Thomaas.
Lewis Foreman Day.	Professor John Millar Thomson, LL.D., F.R.S.
Joseph G. Gordon.	<i>Sir John Wolfe-Barry, K.C.B., F.R.S.</i>
<i>Earl Grey.</i>	
Henry Graham Harris.	

TREASURERS.

B. Francis Cobb.	Sir Owen Roberts, M.A., D.C.L., F.S.A.
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SECRETARY.

Sir Henry Trueman Wood, M.A.

On the motion of the CHAIRMAN, a vote of thanks was passed to the Scrutineers, which was carried unanimously.

Sir MANCHERJEE BHOWNAGGREE, K.C.I.E., M.P., proposed a hearty vote of thanks to the Chairman for his services as Chairman of the Council, an office which he had so well filled for two years. He agreed with the Chairman and Mr. Martin Wood that the Society had been performing most valuable

and instructive work, in a manner which was a credit to its members, and he was sure that the meeting would agree with him that much of the success of the Society was due to the energetic and cordial manner in which the Chairman carried out his duties. One thing that struck him as to the circulation of the *Journal* was that the many excellent papers connected with India were not sufficiently known in that country. He should like to see the papers and lectures published in India itself, especially in the vernacular. He also wished arrangements could be made by which the meetings might be attended by young Indian gentlemen who were studying in London, as he thought it a great pity that papers and lectures so well prepared should miss that very audience among whose members they would have the greatest effect.

The resolution was seconded by Captain W. de W. ABNEY, C.B., F.R.S., and carried unanimously.

The CHAIRMAN acknowledged the vote of thanks, and the meeting then adjourned.

Miscellaneous.

PARLIAMENTARY REPORT ON SECONDARY AND OTHER SCHOOLS.*

The Education Department has long ago collected and published statistics on our public elementary instruction. University education has also been fairly well mapped out and surveyed, but the ill-defined region of intermediate education that lies between these two extremes has till quite recently never been made the subject of statistical analysis. Isolated attempts have indeed been made here and there to reduce to figures the numbers of schools and scholars, as in case of the Royal Commission of 1894, which inquired into the secondary education of seven selected counties in 1895, and analogous investigations were conducted by the Technical Board of the London County Council with regard to similar schools in London. But the first really comprehensive census that has been made, is that embodied in the exceedingly interesting report that has just been issued by the Department of the pupils in public and private secondary and other schools (not being public elementary or technical schools) in England (excluding Monmouthshire), and of the teaching staff in such schools.

The Lords of the Committee of Council on Education seem to have made use of every possible source of collecting information. They pressed into their service the Charity Commissioners, the Science and Art Department, the Technical Instruction Committees, the School Boards, and other local authorities. As a second line of reserves, they called upon the Committee of the Headmasters' Conference, the Association of Incorporated Headmasters, that of

* By Cloudesley S. H. Brereton, M.A. Cantab, L. & L. Paris.

Headmistresses, that of Organised Science Schools, that of Technical Instruction, not to mention the College of Preceptors, the Teachers' Guild, and the National Association for the Promotion of Technical Education. Thirdly, they summoned to their assistance the Educational Committee of the House of Convocation, the Roman Catholic bishops, the high officials on the educational Boards of Congregationalists, Wesleyans, and the Society of Friends. The Oxford and Cambridge Local Examination Boards and other examining bodies came to their aid; Messrs. Macmillan and Longman also rendered them great service, but even when they had exhausted these sources of information, they had by no means arrived at the end of the list of private schools. In fact, the numbers will never be known till compulsory registration of schools is adopted. But compulsory registration of schools is insufficient in itself unless "grading" of schools is also introduced, which implies the necessity of State inspection of the class and kind of education given. At present, the highest secondary schools, such as Eton and Harrow, have to be classed with preparatory secondary schools, and even with the schools that are not secondary at all, because any other form of census is impossible. The memorandum attached to the return is an eloquent statement of the existing chaos in secondary education, and without directly proposing any remedies, is a plain exposition to those who can read between the lines, of the evils which at present prevail, and which future reform will have to take in hand.

But the report goes further still; statistics are given of the school supply under the various counties and county boroughs, which clearly indicates that when the question of dealing with the areas of local education authorities comes up in any future Bill, the county and county borough will be taken as the unit of control, though no hindrance will be placed in the way of several areas combining in one, if local interests are served thereby.

Similarly, the private schools are tenderly treated. Their services in the past are handsomely acknowledged. Their Lordships even go out of their way to print two exceedingly pathetic letters from innocent sufferers from the present state of things. A short quotation from one will give the general tone.

"The Government has taken away the means of our gaining a livelihood out of our hands: surely, in the name of common honesty and justice, some portion of the immense sums of money now spent in education might be given to those women of some degree of culture and refinement who have borne the heat and burden of the day as teachers, and now, at the eventide of life, find themselves heavily handicapped and unable to make things meet. So little would be so great a boon, if certain. Scholarships and certificates were things undreamed of in a woman's career in my youth, and 'sans' certificate in a teacher of to-day means 'sans' everything."

Their Lordships regard these hard cases as a fit subject for the attention of local authorities. But have

local authorities any more right than imperial to apply public money to these undoubtedly deserving cases?

Startling figures are given of the way in which the schools given in the report are understaffed. Sixty-two per cent. of the whole have no graduate on their staff. The total number of schools is 6,209, and of scholars 291,544 of which 158,802 are boys. The per-centage of boys to the whole population is 5·4, and of girls 4·5; which shows that a large number of the latter still receive their education under "domestic conditions."

The pupils are also arranged under successive years from 8 to 19 and over. For boys, the year which has the highest per-centage is that under 14, and for girls that under 8. The schools are further split up into private enterprise, subscribers', companies', endowed, and local authority schools. For boys, the private enterprise schools are the most numerous, but the endowed have the largest population. The girls' schools, both in numbers and population, are overwhelmingly private, as are also the mixed. Boarders in boys' schools amount to no less than 35·7 of the total; in girls', to 18 per cent.; and in the mixed schools to about 12 per cent. 224 boys' schools have no day boys, 101 girls, and 18 mixed are also entirely boarding establishments. Of areas, Kent and Surrey seem the best supplied, due, no doubt, to the large number of preparatory schools they contain.

Peculiarly significant is the omission of technical schools from the report. Are we on the eve of a definite division between secondary and technical education? There seems to be much to be gained from such a judicious separation. The opinion of educationists in Europe to-day (*teste* the Antwerp conference) seems distinctly in favour of keeping general education as clear from specialisation as possible, the idea being that the technical schools are the greatest gainers thereby, as the pupils who come to them from the ordinary schools, after receiving a thoroughly systematic general education, prove themselves far apter scholars than those whose instruction has consisted of a disconnected "smattering" in general and technical subjects.

Obituary.

CAPTAIN W. H. DAVIES.—Mr. William Henry Davies, managing director of the Exchange Telegraph Company (Limited), died on Tuesday, 21st ult., at the age of 73. Prior to his connection with this company, of which he was one of the founders, in conjunction with the late Sir James Anderson and Mr. Cyrus Field, he was in the service of the Pacific Steam Navigation Company and the Peninsular and Oriental Steamship Company. When agent for the P. and O. Company at Aden, he rendered services to the Government in coaling the transport ships of the Abyssinian expedition in 1868, and he received from the Lords of the Admiralty a service of plate in acknowledgment of these services. He was elected a member of the Society of Arts in 1873.

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*All communications for the Society should be addressed to
the Secretary, John-street, Adelphi, London, W.C.*

Proceedings of the Society.**CANTOR LECTURES.****THE THERMO-CHEMISTRY OF THE
BESSEMER PROCESS.**

BY PROF. NOEL HARTLEY, F.R.S.

Lecture I.—Delivered March 14, 1898.

The more points of view from which we regard any object the more complete must be our knowledge concerning it. Hence I propose to consider the chemistry of the process of steel manufacture from the usual view of the chemist, to regard it also from the position of those who have devoted some attention to thermo-chemistry, and by taking one step further, in the light of the most recent spectroscopic research.

In the year 1856, at the Cheltenham meeting of the British Association a paper was read "On the Manufacture of Iron and Steel without Fuel." Some ridicule appears to have been cast upon the proposed process of manufacture, on account of the apparently absurd idea of obtaining a fluid mass of malleable iron and maintaining it in a molten state, by blowing cold air through molten pig-iron, the melting point of the former being much higher than that of the latter. That indeed was the essence of the process. The Reports of the British Association contain no more than the title of the paper, the author of which was a gentleman known as "the ingenious Mr. Bessemer." It had, however, been observed, as was pointed out to the Iron and Steel Institute in a Presidential address by Sir Isaac Lowthian Bell, that in the ordinary refining of iron, towards the close of the process an intensely high temperature is maintained simply by the action of the blast upon the metal and not upon the coke used in the refinery. Bessemer's difficulty in obtaining a suitable pig-iron in England for the purpose of treatment in the converter was overcome by a special pig-iron

being smelted for him at Workington. He dictated the charges from which subsequently the metal was made, and stamped B.* It was necessary that the metal should be free from phosphorus, and such could be smelted from pure hæmatite ores. Now, though samples of wrought-iron as well as steel were produced by this process, which by chemical analysis were proved to be of great purity, yet the metal was found to be worthless as a metallurgical product. It was unworkable, or "red-short." A century previous to this Bergmann had shown that manganese was a constituent of Swedish iron, and he connected this fact with its special suitability for the manufacture of steel. By the introduction of manganese into ordinary cast-steel Josiah Marshall Heath greatly improved the quality of manufactured steel.

Certain iron ores, especially those containing siderite as at Brendon Hill, Somersetshire, and the Siegen district of Germany, also in Styria, contain much manganese, and when smelted they yield a peculiar variety of metal of a highly crystalline character which contains both carbon and manganese called *spiegeleisen* or specular iron, it having in some degree the appearance of specular iron ore. Mr. Robert Forrester Mushet removed the defects in the steel made by the new process by the addition of *spiegeleisen* to the metal in the Bessemer converting vessel. Thus either malleable iron or steel was obtained in large quantity and most economically.†

I propose now to give an outline of the Bessemer process and its various modifications, and an account of the phenomena observed while the process is in operation.

In common language the Bessemer or pneumatic process consists in running molten pig-iron into a large globular or retort-shaped vessel made of refractory firebrick or other infusible material, with an outer casing of iron, and blowing a blast of air in at the bottom, by which means the oxygen in the air oxidises certain compounds of carbon, silicon, and manganese in the metal so as to remove them from the bath and refine the metal. In order to prevent the burning of the iron at the close of the process or to restore to the metallic state any oxide of iron formed, and add to the metal any desired per-centage of carbon, a suitable proportion of the *spiegeleisen* already mentioned is added. In certain cases, as pointed out by M. Euverte, it is not desirable to add carbon, but manganese is necessary to render the metal

* "Journ. Iron and Steel Inst." (1870), p. 24.

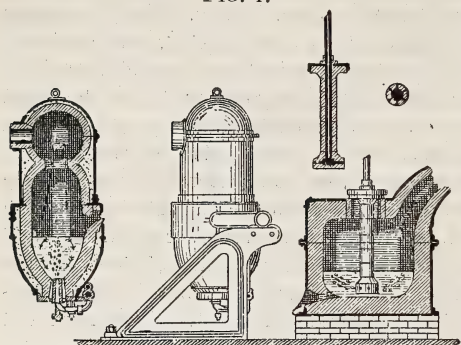
† "Proc. Iron and Steel Inst.," vol. 1, p. 20, 1873.

malleable; ferro-manganese containing 70 per cent. of manganese is added.

DESCRIPTION OF THE CONVERTER.

There is considerable historical interest

FIG. 1.



MOVABLE AND FIXED CONVERTERS, WITH EXTERNAL AND INTERNAL TWYERS.

attached to the early or antique forms such as the globular vessel with a central air shaft

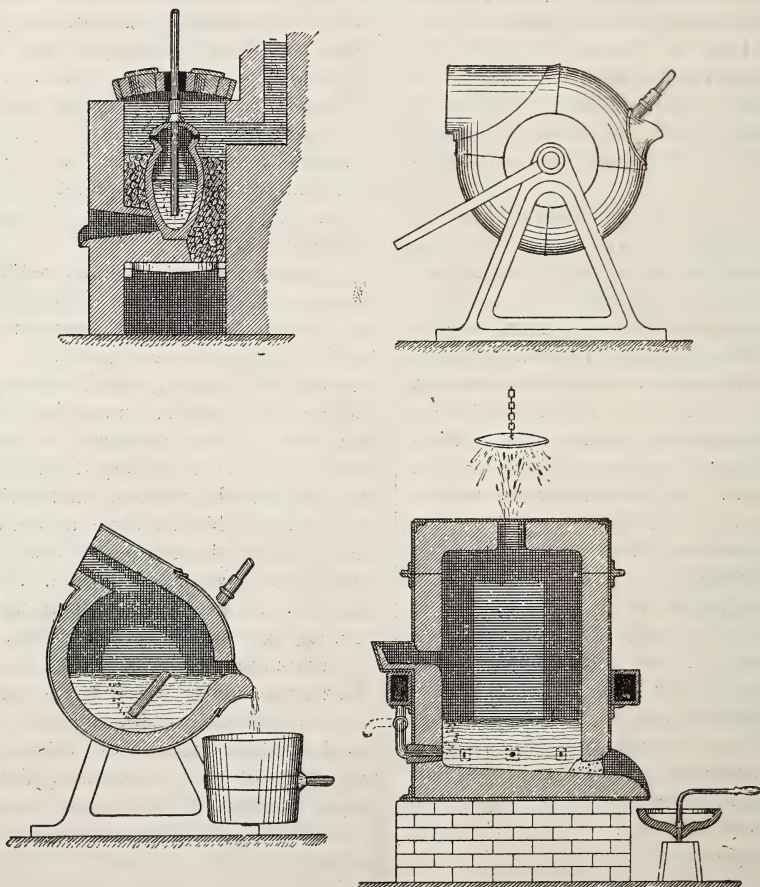
to be raised and lowered, or the converter fixed on a base, because latterly small converters have been devised which partake of the character of some of those originally designed by Bessemer, and we may therefore with advantage just glance at these, but I will describe more carefully the form which is commonly used.

Bessemer's first patent, dated October 17th, 1855, was granted for an invention which consisted in "forcing currents of air or of steam, or of air and steam, into and among the particles of molten crude iron, or of re-melted pig or refined iron, until the metal so treated is thereby rendered malleable, and has acquired other properties common to cast steel, and still retaining the fluid state of such metal, and pouring or running the same into suitable moulds." (Figs. 1 and 2.)*

It is a point of considerable interest and im-

* These illustrations (Figs. 1 and 2) are taken from Sir Henry Bessemer's paper in the "Journal of the Iron and Steel Institute," ii., 1886, p. 638.

FIG. 2.



A MOVABLE CONVERTER WITH EXTERNAL TWYERS, AND A FIXED ONE FOR SIDE TWYERS.

portance that the inventor knew that steam cools the metal, but air causes a rapid increase in its temperature so that it is seen to pass from a red to an intense white heat.

On December 17th of the same year Bessemer patented blowing air through molten iron in a spherical or egg-shaped vessel of iron, lined with fire-brick, and suspended on axes. In May, 1856, he patented an immovable, upright cylindrical vessel with several air tubes fixed into the lining of the vessel at the bottom. This was long in use in Swedish Bessemer works.

The movable converter universally employed in England, after a time superseded the fixed converter, and became generally adopted on the Continent. It affords great facilities, not only for charging it with metal, but also allows of the charge being retained after the blast has been cut off, and it admits of the operation being interrupted and resumed at will; furthermore, the metal is easily poured out.

A shell of strong wrought-iron plates is suspended by means of a wrought-iron hoop which carries trunnions supported by cast-iron standards. While one of these is solid, the other is hollow, and through the hollow trunnion the blast passes to the bottom of the vessel. The bottom, which is removable, is fixed in its place by cotter bolts. Below the bottom is the twyer box, a cylindrical chamber which, by means of a pipe curved outside the converter, conveys the blast from the hollow trunnion. The twyers are slightly tapered cylinders of firebrick, each one perforated by seven holes of half-an-inch in diameter. The twyers are from five to seven in number arranged at equal distances from each other. They pass through the iron plate which forms the top of the air chamber. The solid standard carries gearing which is actuated by hydraulic machinery acting vertically. By the rotation of the converter upon its axis, the blast is automatically cut off just at the right moment. An eccentric disc acting on a lever lifts a valve and turns on the blast as soon as the converter is in the proper position again for blowing. But when the converter is lowered for the purpose of pouring out the metal, the pressure is taken off the lever and the blast valve is closed.

The interior of the wrought-iron vessel is lined with very refractory firebrick or with ganister, a highly siliceous sandstone with a fine grain. It is prepared for the purpose by being finely ground; mixed with powdered firebrick it is moistened with a small quantity

of water and rammed into the space between the outside casing and a wooden core, which is afterwards withdrawn.

Usually two converters are placed at opposite sides of a circular casting pit, in the centre of which a vertical hydraulic cylinder carrying a cross arm, to one end of which is fixed a ladle for the metal, which is counterbalanced by a weight at the other end of the arm. The counterpoise is geared in such a manner that it is moved gradually towards the centre as the weight of metal in the ladle is diminished by its being tapped. This ladle is made of strong iron plates thickly lined with fireclay.

The tap-hole is at the bottom, and is closed by a bent iron bar carrying at its lower end a plug, both of which are coated with fireclay. The end of the bar turns outside the ladle, and is connected with a hand lever, which operates on the bar to raise or lower the plug in the tap-hole and admits or cuts off the flow of the metal. Around the casting pit are arranged the ingot moulds, and when the ladle is carried round by the circular revolution of the horizontal cross arm which supports it, the tap-hole is brought successively over the mouths of the several ingot moulds.

A foreman stands on a platform commanding a distinct view of all operations, and from this point controls the machinery for tipping the converters and discharging the metal into the ladle and into the ingot moulds.

The upper end of the converters during the operation of blowing discharges sparks into open air or under a wide flue. The first operation necessary is to heat the converter to redness and this is done by charging it with ignited coke which is made to burn within the vessel by a blast being driven through the twyers. Ashes and unburnt fuel are emptied out of the vessel by tipping it mouth downwards. It is then brought to a horizontal position to receive a charge of molten metal. This may be pig-iron melted in a reverberatory furnace or in a cupola furnace, but what is far better, being more economical, is freshly smelted metal carried direct from the blast furnace in a molten state. This was Sir Henry Bessemer's first idea, but it had to be abandoned because the process could not be properly controlled. The metal tapped at different times from different furnaces or even from the same furnace, differs in composition to such an extent that the treatment in the converter of one charge may be quite unsuitable for the next.

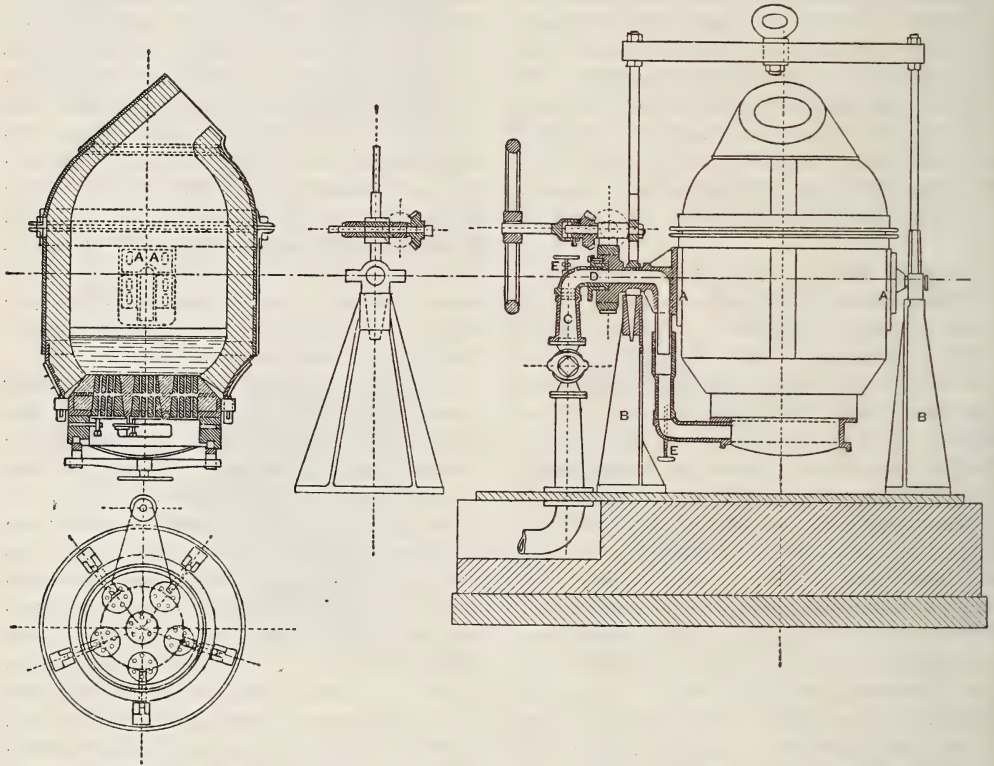
To modify the treatment for each charge is

impracticable, hence it is necessary to obtain iron suitable for uniform treatment. The cost and waste of re-melting pig-iron in cupola furnaces was subsequently avoided by reverting to this mode of treatment. Charges of 20 tons of pig-iron are run at one time into a hot vessel conveyed on rails by a locomotive for a mile or two to the converters. The metal keeps hot for hours if necessary. To say nothing of the cost of re-melting pig-iron, the molten blast

iron of regular composition, capable of uniform treatment in the converter, is thus obtained, which greatly facilitates the manufacture of a product with a uniform composition.

Holley's converter is an improved form of vessel (English patent, 1870) of an elongated and cylindrical shape, made so as to prevent the ejection of slag and metal by the blast. It was further fitted with a removable bottom,

FIG. 3.



DAVY'S 10-CWT. PORTABLE CONVERTERS.

The form of this vessel is similar to large Bessemer vessels in general use.

furnace metal is more economically conveyed in a ladle than cold pig-iron was placed in waggons and unloaded again at the cupola. It is now found advantageous to tap the metal from different blast furnaces and then to mix it thoroughly. This is done by what is known as the Hoerde Mixer, invented by Massenez, of the Hoerde Works in Styria, and the metal is known technically as "mixer metal."* A fluid

so arranged that the joint between the old lining and the new bottom could be made from the outside.

The Clapp-Griffiths converter is an improved American form of fixed vessel, in principle like the form used for a long time in Sweden. (Fig. 4.)

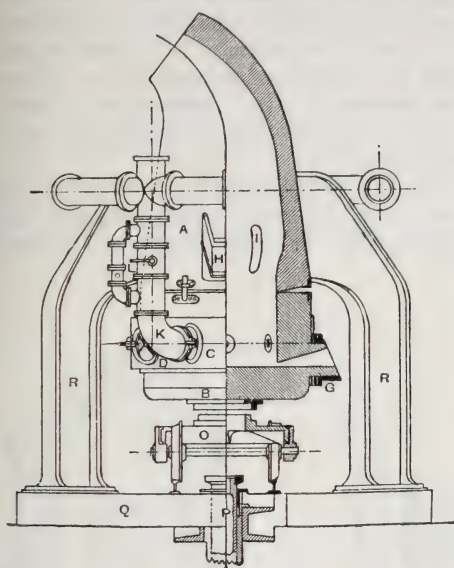
The Walrand-Delattre converter (Fig 5,* p. 710) is a moveable vessel in which the blast

* Mr. Arthur Cooper's paper "Metal Mixers as used at the works of the North Eastern Steel Company, Limited." "Journ. Iron and Steel Institute," vol. xlvii., p. 66, 1895.

* These illustrations (Figs. 3, 4, 5) are taken from Mr. Hardisty's paper in the "Journal of the Iron and Steel Institute."

is delivered at the side, and at or near the surface of the metal. There is but little difference between this and what is now known as the Robert converter.

FIG. 4.



WITHEROW'S MODIFICATION OF THE CLAPP-GRIFFITH VESSEL.

As described by Mr. T. Lynwood Garrison* the peculiarities of these forms are such that a smaller pressure of air is required, because, by the blast causing the metal to rotate, the air comes successively into contact with every portion of it, but instead of the air passing through the bath and overcoming a considerable pressure, it enters nearer to the surface. How this is effected, both in the Walrand-Delattre and in the Robert vessel, the illustrations and description will explain.

The vessel is elliptical, having a flat surface, in which the twyers are placed on a plane parallel to the axis of the apparatus. It has a swinging movement on its trunnions, which are supported upon massive bearings. By suitable mechanism the swinging movement disengages the twyer from the metal bath.

The twyers, placed horizontally, form with the flat surface unequal angles varying with the transverse section of the apparatus, and thus the rotary motion communicated to the metal bath brings every part of it successively under the operation of the oxygen in the air of the blast. The movement causes a regular and methodical rotation of the metal so as to

prevent too prolonged a period of decarburisation.

When the charge has been run into the converter, it is tilted into position and the blast is turned on as soon as the metal reaches the level of the twyers. An escape of sparks with a spiral motion is seen at the mouth of the converter. The slag separates from the metal and gases escape. When the level of the bath is about an inch below the twyers, the blast is turned on. This causes a spray of metal with a considerable rush of sparks as the iron burns. The apparatus is raised gradually, and the sparks diminish as the greater volume of air passes along the surface of the bath.

A duller noise is caused by the blast when the molten metal arrives at the level of the twyers, and the sparks increase. The blast is then stopped, and the lighting of the gases takes place within the converter. When the sparks diminish and change colour, the apparatus is gently raised until the flame begins to issue from the mouth—and in this position it is stopped. It is only when the gas is well alight that the apparatus must be further raised, until it arrives at a position when, if the blast were shut off, the twyers would be covered by about $1\frac{1}{2}$ inches to 2 inches of metal. The pressure of the blast is, on an average, about 4 lbs., just sufficient to keep the slag out of the metal, and to rotate the bath.

The first period of the blow lasts from seven to eight minutes, the second from three to four. At the end of the second period the flame disappears, and it might be supposed that the carbon has been removed. A third period succeeds of $1\frac{1}{2}$ to 2 minutes' duration, in which the flames reappears and is of considerable size. As a rule the blows are quiet. As soon as the flame drops, after this third period, the converter is turned down, and about 1 per cent. of ferro-manganese is added containing 70 per cent. of manganese.

The converter is then allowed to rest for about ten minutes to allow the ferro-manganese to melt and diffuse into the iron. It may be added to the metal after it has been poured into the ladle. For steel casting, ferro-silicon may be added to the molten contents of the ladle, to the extent of not more than 0.008 of ferro-silicon having 10 per cent. of silicon; a larger quantity would be injurious to the quality of the steel. This form of converter is small, being of about three tons capacity.

It is claimed for this process that the quality of the steel can be regulated with great nicety. There is no novelty in blowing air on or near

* "Journ. Iron and Steel Inst.," p. 266, 1889.

the surface of the metal bath because this was the subject of some of the first experiments of Sir Henry Bessemer, but he found it produce no abnormal quantity of slag and a dense brown fume caused by the burning of the iron. In all cases and with whatever shape of converter he found the result to be better the lower the twyers were placed.

It appears to be doubtful whether the rotatory circulation of the metal takes place to the extent which is implied and in the regular manner described.

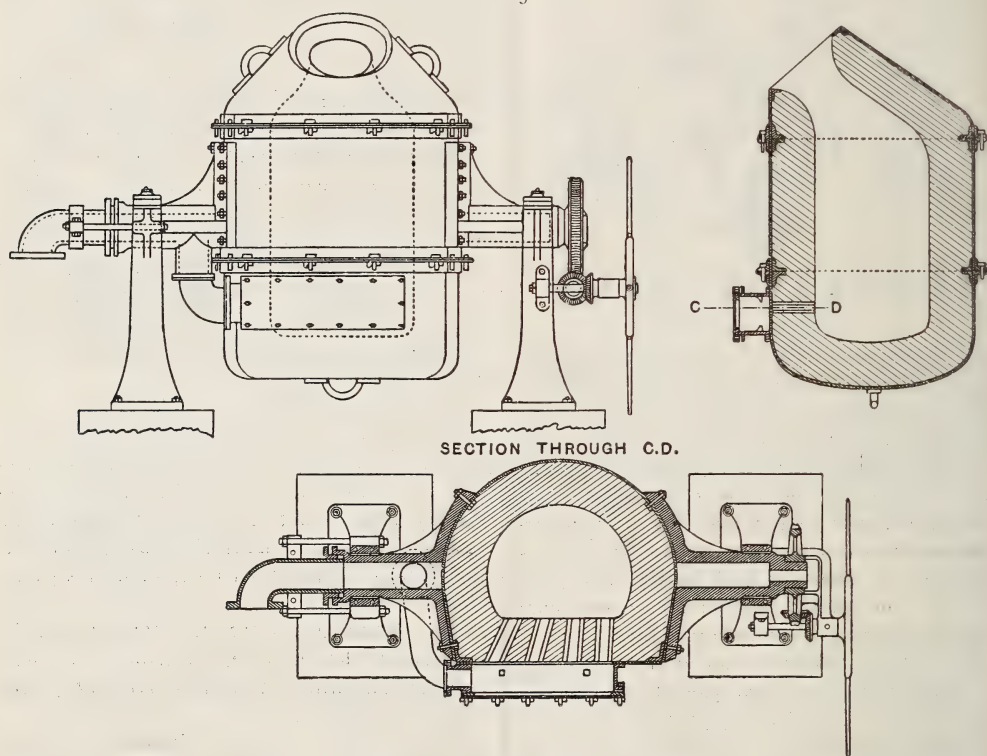
The loss is about 12 per cent. varying to 18 per cent. according to variations in the method adopted.

It is designed for the production of steel castings of comparatively small dimensions as compared with ingots, such as for instance the metal used by makers of mining machinery and agricultural implements.

In the use of small converters a difficulty always occurs owing to the bath of metal being at too low a temperature. The blast in fact cools it. In different circumstances this has been obviated by the addition of (a) ferro-silicon, or (b) of ferro-phosphorus or phosphorus slag.

When these substances are added to the bath during the "boil," the combustion was deadened by the large quantity of carbonic

FIG. 5.



THE WALRAND CONVERTER.

It is stated that a very high temperature is produced and that the steel remains perfectly fluid for at any rate 35 minutes after blowing has ceased. M. Le Chatelier has measured the temperature of the steel in the ladle of the Robert converter and found it to be 1600° C.

THE WALRAND-LEGÉNISEL CONVERTER.

This is a converter of small size similar in form to the later designs for large vessels, the twyers entering at the bottom of the vessel.

oxide present, and a considerable quantity of heat was carried off by the current of gas. This led Walrand to add the material termed ferro-silicon only after the combustion of the carbon had entirely ceased or at any rate was nearly completed. In this manner a new combustion was started, and complete success resulted; an addition of five per cent. of molten ferro-silicon produced an increase in the temperature of at least 200° C., within a few minutes of blowing. By the addition of the

ferro-silicon it is possible to carry the combustion of the remaining carbon further than by the older method without using an excessive quantity of oxygen, and in consequence only small additions of ferro-manganese are required to de-oxidise the blown metal.*

THE TROPENAS CONVERTER.†

This latest development of diminutive Bessemer converters, is a form of perfected Robert vessel in which there are two sets of twyers, the lower series drives the blast just over the surface of the metal, the upper set of smaller size is supplied with air by a separate blast box, which during the progress of the

type which heats the air coming from the blowing engine to the twyers. Oxidation takes place at the surface of the bath of metal only, and it is claimed that there is no stirring movement and mixture of slag with metal during the blow so that the impurities in the slag do not get back into the metal. The temperature of steel being very high admits of it being removed from the converter in small quantities at a time for casting purposes. It is stated that the reaction is transmitted from molecule to molecule from the surface throughout the bath to the bottom, but unless there is movement of the metal this can take place only by diffusion of oxidised products dissolved

Fig. 1.

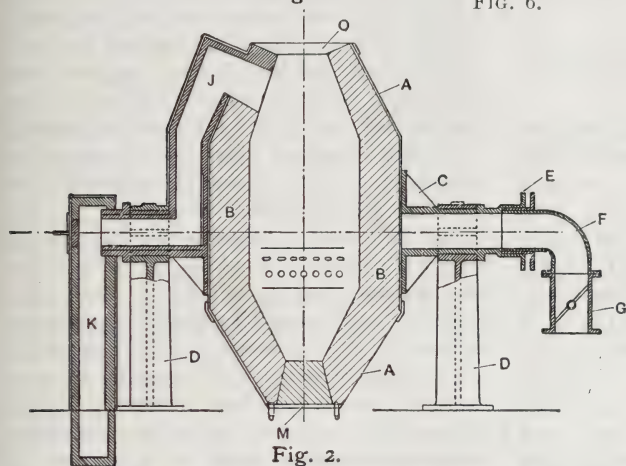


Fig. 2.

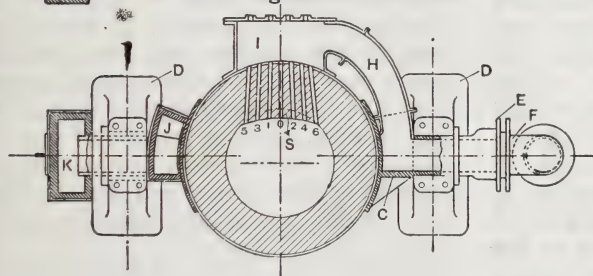


FIG. 6.

Fig. 3.

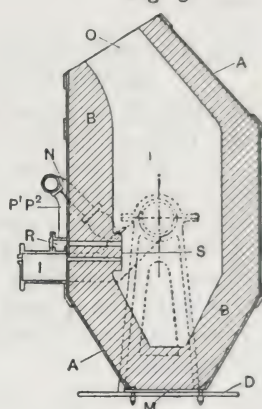
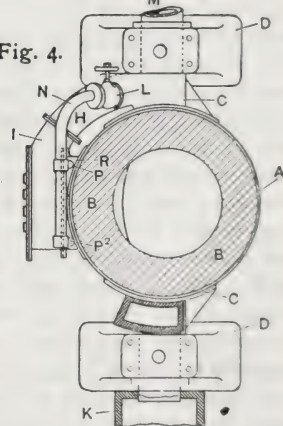


Fig. 4.



THE TROPENAS CONVERTER.

boil admits air merely for the purpose of burning the carbon monoxide *inside the vessel* and greatly increasing the temperature whereby the metal maintains its fluidity. There is also an outlet provided near the upper part of the vessel for hot gases to pass through a hollow trunnion into a regenerator of the Siemens'

in the bath such as Fe_3O_4 and CO , or by rapid diffusion of oxidisable impurities bringing them to the surface. The former action would operate much more rapidly than the latter, and oxidation taking place beneath the surface would no doubt give rise to the ebullition of CO and thorough mixing of the metal, but not of metal with slag. This method of blowing obviates the inconvenience and loss occasioned by the projection of metal and slag

* "The Walrand-Legénisiel Process," "Jour. Iron and Steel Inst.," vol. xlv., 1894, p. 26, by G. J. Snelus, F.R.S.

† "Jour. Iron and Steel Inst.," vol. i., p. 34, 1897.

from the mouth of the vessel, which is a feature of the ordinary process. It is claimed also that owing to the bath being comparatively quiet there is less waste from oxidation. However this may be, it is a fact that a slag very rich in iron is produced at one period of the blow. At a later stage some of this slag has metallic oxide contained in it reduced either by action of manganese carbide in the bath or of the highly-heated carbon monoxide.

At works in Sheffield two converters made five "blows" in an average of an hour and fifty-five minutes, the weight of steel for each blowing averaging from 30 to 32 cwt. The process may be either *acid* or *basic*, and ferro-silicon or ferro-manganese finally added. This process appears to be in use at Woolwich Arsenal.*

THE THOMAS-GILCHRIST OR BASIC BESSEMER VESSEL.

The chief difference in the vessel designed for the Thomas-Gilchrist or dephosphorising process, which is built to contain changes of as much as twenty tons of iron, is a more cylindrical form, with a wider mouth of shorter length than that of the old form of Bessemer converter. This prevents the opening from being choked by slag, which is formed in much larger quantity than in what is known as the "acid process."

The lining of the converter is also totally different. An acid lining is one composed of sand or silica, or highly siliceous brick, since the different forms of silica combine with metallic oxides to form silicates or slags. A basic lining is one composed of lime or other basic oxide capable of withstanding a high temperature without fusion. Such a lining combines with acid-forming oxides such as that formed by the oxidation of phosphorus, and does not combine with any basic material such as lime, which may be added to the charge for the purpose of combining with and removing the phosphorus after it has been burnt by the blast, so that it shall not re-enter into combination with the iron. The use of burnt lime, for the purpose of removing sulphur and phosphorus from iron, was, it appears, first recommended by Dr. Collyer.

The basic lining for converters appears also to have been suggested by Professor Gruner, but it was some years later that, in looking about for a refractory basic material that could be made into bricks, Mr. G. J. Snelus found that a magnesian limestone containing a small

quantity of iron in the form of oxide could be so indurated by the action of fire that moisture would not cause it to slake. But to Messrs. Percy Gilchrist and Gilchrist-Thomas, the credit of devising a process for removing phosphorus from the iron is due, the working of the process on a large scale being carried out by Mr. E. Windsor Richards.

THE ARRANGEMENT OF PLANT IN BESSEMER WORKS.

The various arrangements of Bessemer plant have been designed for purpose of working with convenience and expedition without extra labour, and in this the American engineers have excelled.

The essential difference between the English system as devised by Bessemer and the American by Holley, is that in England the converters are placed face to face, and thus little more than half the circle traversed by the casting ladle can be used for placing moulds, but in the American plant the converters are placed side by side, so that about four-fifths of the circle are available for moulds.

The difference in output was 350 tons of ingots per week in England, as against 500 tons or more in the United States. Such work, however, was secured by Holley's renewable bottoms for the converters, which, ready dried, are capable of being fixed immediately after the old bottom has been removed, and by intermediate receiving ladles for conveying weighed charges of metal to the converters. It appears that the practice in America of blows of short duration, with short intervals between the blows, is really necessary, because there is but little silicon to be removed. By rapid blowing, a large amount of heat is evolved in a short period, and the interval between two blows being short, there is relatively very little loss of heat from the vessels.*

THE CHEMISTRY OF THE BESSEMER PROCESS.—THE VISIBLE EFFECT DURING "BLOWING."

When a converter has been heated and charged with metal, it lies in a horizontal position, and until brought to a position when the molten metal begins to run over the twyers, no air passes, because the blast valve has not yet been opened. Directly, however, the air is forced through the twyers, the vessel gradually assumes an erect position, and then blowing begins, the whole apparatus, and even

* *Engineering*, January 14th, 1898.

* H. M. Howe, A.M., S.B., "Notes on the Bessemer Process," "Jour. Iron and Steel Inst.," vol. ii., 1890.

the ground upon which it stands, is shaken with the violent agitation taking place in the heated mass of liquid iron. Molten iron by the hundredweight is projected upward, which falls back again and encounters the blast. There can be no doubt of complete mixing of the metal and of contact with the blast. A roar comes from the mouth of the vessel, accompanied by an irregular and intermittent violet flame; next the flame becomes continuous, less transparent, and it changes to yellow. Gradually becoming whiter, it becomes denser and larger, that is to say, longer, and intensely brilliant. There are now no irregular eruptions, but a steady roar, the metal being hotter and much more fluid. The sparks ejected during the earlier stages are larger, and particles of iron, or of ferrous carbide, burn in the air with vivid scintillations, being composed of drops of metal with graphite in them, or containing ferrous carbide; the sparks become smaller and hiss without throwing out other sparks. They can change to brilliant stars of a bluish colour appearing to float in the flame.

Occasionally lumps of molten slag are thrown out, but more often they reach only to the mouth of the converter and fall back into it. Sometimes the heat of the charge becomes so much increased that the air passes freely through the highly-fluid metal and combustion rapidly increases them, the flame becoming very brilliant and long is accompanied by bursts of sparks, slag, and metal. This is technically called "blowing wild," and the progress being too rapid is less under control than it should be and the temperature is too high. It is then necessary to turn down the converter to stop the blowing and cool the charge.

Inside the converter a liquid slag is seen floating on and completely covering the metal. Sometimes cooling is effected by throwing in solid pig-iron, sometimes an old ingot mould is charged into it, and I have even seen a charge cooled with one or two buckets of water which were thrown right on to the slag. When the large brilliant flame is seen, the metal is at the stage known as the "boil," but presently its brilliancy and density begin to diminish, the flame becomes amethyst in colour, and also transparent or thin; it is coloured yellow only at the edges and near the mouth of the vessel; it becomes irregular, then somewhat shorter, and finally it drops suddenly within the mouth, at which instant the converter is turned over on its back and the blowing ceases.

Into the molten metal there is now run either a charge of spigeleisen or of ferro-manganese. The former is delivered by a spout or gutter from a cupola furnace in which it has been melted, or from a ladle; the latter is thrown in a red-hot solid state. A few seconds of blowing stirs up and mixes the two metals or even resting for a few minutes, and then the liquid mass is poured into the ladle. After the last of the metal has been poured out the converter is tipped up so as to empty it by draining off the slag. Before it has time to lose much of its heat another charge is introduced and blowing re-commenced.

The experiment I am about to show you gives on a small scale some idea of the colour of the flame and of the sparks. I am burning in the oxy-hydrogen blow-pipe powdered ferro-manganese, and you will observe the peculiar yellow colour and intense luminosity of the flame, this is due to the combustion of manganese. I can show this to you now by substituting a piece of Bessemer slag essentially a manganese silicate in composition, and you observe the same colour communicated to the flame. The intensity of the flame is such that when photographed on a day with a cloudless blue sky, it appears intensely white against a dark background, which is an indication of its great brilliancy and photographic power. (Two photographs taken at Dowlais were thrown upon the screen which very clearly showed this.)

Now, during the whole period, but more especially near the close of the "blow" a large amount of flame is given off from the converter, this condenses in the cold air to minute spherules of brown ferruginous matter, it has a chalybeate flavour, and is evidently composed largely of iron and no doubt manganese. It has been analysed by Schöffel for Brunner, and its composition suggests the volatilisation of silicon, silica, or some silicon compound.

Analyses of fume from a converter during the fining period, gave the composition FeO , 16.20 per cent.; SiO_2 , 34.86 per cent.; MnO , 48.23 per cent. (Schöffel). This roughly is represented by $\text{Mn}_3\text{Si}_2\text{O}_7$ or $(\text{FeMn}_2\text{Si}_2\text{O}_7)$.

THE COURSE OF CHEMICAL CHANGE.

The course of chemical change which takes place in the converter was first studied by Mr. G. J. Snelus, F.R.S., who gave (*Chemical News*, vol. xxiv., p. 159, 1871) the original composition of the pig-iron blown, and of the metal in the vessel at different stages in the

analyses of the slag removed at different times and of the gas issuing from the converter. The latter was a work of great difficulty owing to the high temperature. The results of the numerous analyses are best studied when reduced to curves. Fig. 7 deals with a pig-iron containing:—

	Per Cent.
Graphite	2.07
Silicon	1.95
Combined Carbon	1.2
Manganese	0.04

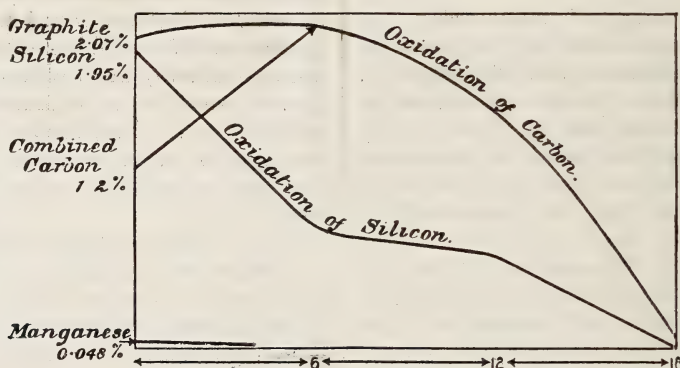
The operation in the acid process when continued for twenty to twenty-four minutes is divided into three periods—

First Period.	Second Period.	Third Period.
Duration, 3 to 6 minutes.	Duration, 12 to 14 minutes.	Duration 4 to 6 minutes.
Formation of slag.	Evolution of gas.	
SLAG PERIOD.	THE BOIL.	FINING STAGE.

and carbon in the bath, and, secondly, a volatilisation of manganese from the bath and also from the slag. Thirdly, the carbon dioxide diminishes rapidly, while the volume of carbon monoxide largely and rapidly increases, causing violent ebullition during its escape. Fourthly there is a production of some hydrogen by the decomposition of water vapour in the blast acting upon the molten metal, but the quantity of course is small, and it will be seen by the curve that it is constant. (Fig. 8.)

During the third period, or fining stage, the product is carbon monoxide from the oxidation of the remaining portion of carbon, but no carbon dioxide, the temperature being too high to admit of its production in presence of iron. There is a ferrous silicate or slag formed until the silicon is quite removed. Hydrogen is steadily produced. A small amount of manganese is volatilised from the slag. Here we have in the metal bath fuel equivalent to $3\frac{1}{2}$ cwt. of coke, while the combustion of the silicon is equal to half as much more, or in all 5 cwt. 28 lbs.

FIG. 7.*



During the first or slag period the following changes occur in the acid process as conducted in England.

1. Oxidation of manganese until this is entirely removed from the metal.
2. Oxidation of the silicon; formation of a fusible silicate or slag with manganese and iron.
3. Combustion of combined carbon, chiefly to form carbon dioxide, but partly carbon monoxide.
4. Graphite is converted into ferrous carbide, that is to say, combined carbon.

From the results of Mr. J. G. Snelus the proportion of CO_2 to CO formed throughout the oxidation of the carbon is as 55.1 CO_2 to 260.2 CO or 17.4 per cent. by weight of the gas.

During the second period, the "boil," there is, first, a steady combustion of silicon

burnt in twenty minutes at a high temperature, and with the aid of compressed air. Kupelwieser has shown in a similar manner by analyses the oxidation of the impurities in a pig-iron of the following composition burnt in a blow of twenty minutes' duration:—

	Per Cent.
Manganese	3.46
Graphite	3.18
Combined Carbon	0.75
Silicon	1.96

First period, or slag formation, lasting eleven minutes:—

1. Oxidation of manganese.
2. Oxidation of silicon and formation of slag.
3. Formation of ferrous or manganese carbide from graphite.
4. Oxidation of ferrous carbide (combined carbon).

* Figs. 7, 8, 9, from "Phil. Trans.," vol. 185, p. 1041. 1895.

Second period, the boil, lasting four and a half minutes, continuous oxidation of silicon, carbon, and manganese.

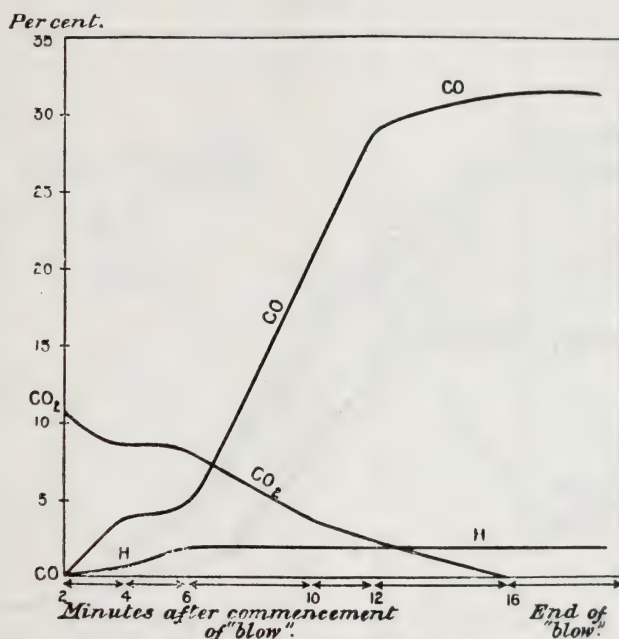
Third or the fining period, duration two and a half minutes, the final removal of impurities, carbon, silicon and manganese.

In addition to the changes thus given in detail, there is, furthermore, in the fining stage an oxidation of iron, also in both the boil and the fining period a volatilisation of iron, and of manganese takes place, and as the gas produced in the converter constitutes a reducing atmosphere at a high temperature, the metallic vapours are carried out of the converter into the air where they are burnt

in the working of the St. Louis blast furnaces at Marseilles in 1878.*

It must here be noted that in working the "acid process," the phosphorus and sulphur in the original pig-iron are not removed, and consequently the per-centage or *proportion* of these constituents in the finished Bessemer metal is increased by so much as the other impurities in the iron are diminished. On this account only very pure hæmatite pig in England, or charcoal pig-iron in Sweden is suitable. Sir Henry Bessemer had at first great difficulty in obtaining a metal suitable for his requirements, and in fact, as I have previously stated, he had it smelted specially

FIG. 8.



along with the carbon monoxide. Hence the production of fume. Towards the close of the fining stage the manganese in the fume is reduced in quantity and the iron is increased.

The curves which I have reduced from Kupelwieser's analyses differ from those of Snelus in detail only, which is owing to the difference in composition of the iron blown, and the timing of the periods being different in consequence, but they are the same in general effect.

The volatilisation of manganese from the metal and from the slag is due to the very volatile nature of this element as was first ascertained and pointed out by Professor Jordan

for him from materials which contained very little sulphur or phosphorus.

THE THOMAS-GILCHRIST, OR "BASIC" BESSEMER PROCESS.

In dealing with the Thomas-Gilchrist or "basic" Bessemer process, it may be mentioned that the great majority of British and foreign iron ores yield pig-irons which are quite unsuitable for treatment owing to the sulphur and phosphorus they contain, but it has now been found that the phosphorus can be turned to a positive advantage.

In describing the "blow" there is a very

* "Comptes Rendus."

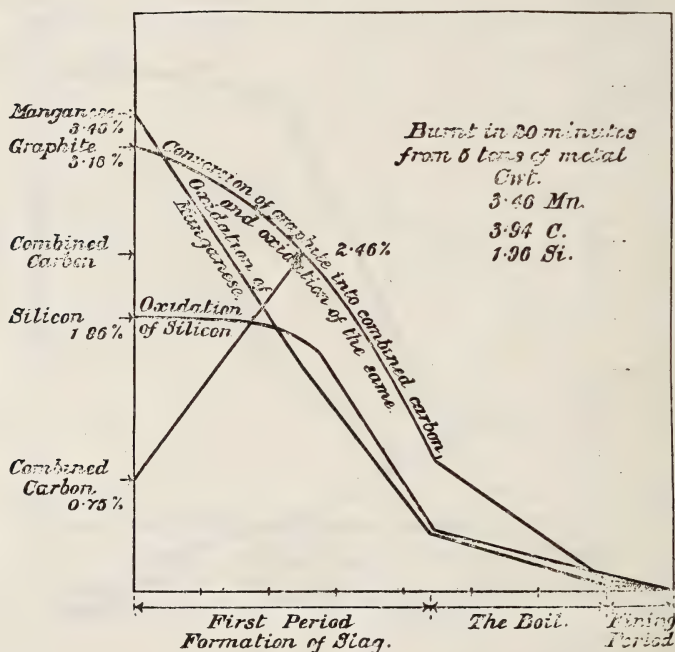
notable fact that from the first the flame from the converter is luminous, the luminosity being apparently caused by gaseous hydrocarbons produced from the tar contained in the lining of the vessel; but luminosity is also caused by basic material, such as lime in the charge. After this initial charge, the progress is very much the same until the fining stage is nearly concluded, when a burst of sparks accompanied by lumps of slag occurs. No doubt the reason of this indication is the stiffening of the slag owing to its accumulation and probably to some extent cooling. At this point the converter is turned down and a sample of metal is removed and broken to ascertain from the appearance of its fracture

yellow, and even appears somewhat similar intensity and colour to the blaze which is seen in making the experiment of burning phosphorus in oxygen. While this is in progress there is nothing to indicate how far the phosphorus has been removed, and lapse of time only determines the finish of the operation. While, therefore, there are three periods in the "acid process" there are four in the "basic" namely, the 1°, slag forming; 2°, the boiling; 3°, the fining stage; and 4°, the phosphorus period, commonly termed the over-blow.

EVOLUTION OF MUCH HEAT DURING THE BESSEMER PROCESS.

The first explanation offered of the cause

FIG. 9.



the quantity of phosphorus to be removed and the time during which blowing must be continued. A quantity of burnt lime is thrown into the converter and the blowing is resumed. This period is termed the "over-blow" or "phosphorus period." As the manganese, carbon, and silicon have gone the blast attacks the iron and phosphorus, and as these materials are not gaseous the flame is not one which burns at the mouth as is the case throughout the "acid process," but in the interior of the vessel, as it extends it appears outside, and along with it are dense reddish clouds of fume composed of iron oxide; it then becomes of a brighter

the very high temperature maintained during the Bessemer blow was that of Professor Jordan, of the École Centrale in Paris, read before the French Society of Civil Engineers May 20th, 1869, and subsequently Professor R. Åkerman ("Jour. Iron and Steel Inst.," 1872, p. 110) specially referred to the heating effect of silicon, but exact data at that time were wanting. He assumed that the temperature of the molten pig iron to be blown was 1,400° Centigrade, and the gases leaving the converter to be also at this temperature. They are certainly not below 1220°—the temperature of molten pig-iron. The intensely high tem

perature maintained is due, not so much to carbon as to the combustion of the silicon, or rather of ferrous silicide, in the pig. In *Engineering*, 1870, ii. p. 200, Lieutenant Dutton gave an account of the chemistry of the Bessemer process, and referred to Prof. Jordan's work. Both practical experience and different methods of investigation have confirmed and justified his conclusions.

TEMPERATURES DEVELOPED IN INDUSTRIAL FURNACES.*

Temperatures taken from a Robert Converter:

Flame at the "boil"	1,330° C.
„ at the finish	1,580°
Of slag after pouring	1,640°
„ steel in ladle	1,640°
„ steel in mould	1,580°
„ solidification of scale	1,340°

Scale of Temperature adopted was that of Violle.

Sulphur, boiling point, 448° C.; Gold, melting point, 1,045° C.; Palladium, melting point, 1,500° C.; Platinum, 1,775° C.

	Melting points.
Swedish white iron	1,135° C.
Grey cast	1,220°
Ingot iron, 0.1 per cent. C.	1,475°
Mild steel, 0.3 per cent. C.	1,455°
Hard steel, 0.9 per cent. C.	1,410°
Siemens-Martin's mild steel in ladle	1,490°
Ingot iron	1,540°
Siemens' crucible steel-melting furnace (temperature of space between the crucibles)	1,600°

With reference to some points already dealt with, it will be convenient to glance at a classification of the different forms of converters which have been and are now in use.

BESSEMER VESSELS.

Fixed.

Old Form.
Swedish Vessel.
Clapp-Griffith.
Witherow Clapp-Griffith.
Hatton.

Moveable.

Improved Old Form.
Holley's.
Thomas Gilchrist.
Walrand-Delattre.
Robert.
Davy.
Tropenas.
Walrand-Légéniscl.

Of these we have:—

The Swedish.
Clapp-Griffith.
Walrand-Delattre.
Robert.
Tropenas.

Used for side-blown charges.

Ordinary Acid Process.

Holley's.
Thomas-Gilchrist.
Walrand-Légéniscl.
Davy.

} For none but bottom-blown charges.

As I have already mentioned the Robert, Walrand-Légéniscl, and Tropenas vessels can be made of a diminutive dimensions, working up small charges of metal such as six or eight hundred-weight.

They have their special uses in the manufacture of steel in comparatively small quantities, for the construction of mining machinery and agricultural implements, and it is probable that their employment will be greatly extended in these and perhaps other directions.

I have dealt with the course of chemical change, and the variation of the different periods in the oxidation of the manganese, silicon, carbon, and the non-oxidation of the sulphur and phosphorus in acid "blows." The duration of the periods is dependent upon the composition of the metal, whether, there is for instance, much silicon or little silicon, much manganese or little manganese.

Two striking examples may be mentioned. It is well known that in the United States blowing is accomplished with great rapidity, in from eight to fourteen minutes; and that special arrangements have to be made for rapid working.

The reason of this has been explained by Mr. H. M. Howe. The iron contains but little silicon and its initial temperature is low, besides which there is a large out-put from the works. The blows are of short duration because there is little silicon to remove, and because it is rapidly removed by supplying a copious blast of air. Even with a small percentage of silicon the heat evolved is sufficient to maintain a high degree of fluidity in the metal because the blows and the intervals between them are so short that relatively but little heat escapes from the vessels, and they remain so hot that another blow can follow immediately upon one that has finished.* Another example is afforded us by the Swedish process, which as already mentioned could be carried out in a fixed converter, and without any final addition of spiegelisen.

The process could be stopped at the right moment by observing the flame. This is due to the large amount of manganese that the

* H. Le Chatelier. C. R., 111, pp. 470-73.

* "Notes on the Bessemer Process." By H. M. Howe, A.M., L.B., Boston, "Jour. Iron and Steel Inst.," vol. ii., 1890, p. 1.

metal contained, which after the removal of the silicon and carbon still left a sufficiency of manganese in the bath to prevent oxidation of the iron by the blast; whether the metal contains much or little silicon, much or little manganese determines the method of working, and the duration of the periods of the blow.

The modification of the process, however, determines the number of periods in the blow, thus: (1) the Acid Bessemer blow has three periods; (2) the Basic has four periods; (3) the Walrand-Légénisiel, whether acid or basic, has four periods; (3) the Tropenas either three or four according as it is acid or basic. In the basic process the fourth period is an over-blow or ferro-phosphorus period, ferrous-phosphide being the substance burnt, but in the Walrand-Légénisiel acid process it is a ferro-silicon period. The gas escapes and burns, and when all the carbon has gone ferro-silicon is added and the over-blow takes place, whereby a high temperature results from the combustion of the ferrous-silicide, and a very fluid metal can be cast. In the Tropenas blow the carbon is burnt off, and the carbon monoxide is consumed in the converter, but the blow may be either "acid" or "basic."

Miscellaneous.

PROGRESS OF BELGIAN VICINAL RAILWAYS.

Last year's working of Belgian vicinal or parish railways, as distinguished from the normal standard-gauge lines (with which latter the country is however abundantly provided), proves the wisdom of the policy which established the comprehensive system of endowing outlying districts with cheap means of communication that has been referred to in previous articles.*

On 31st December, 1896, the Société Nationale des Chemins de Fer Vicinaux, whose offices are in Brussels, held the concession of 77 light lines, together 1,627.53 kilometres long; and during last year that body obtained 22 new concessions of lines and extensions, measuring 193.08 kilometres, so that at the end of last year the length attained 1,823.89 kilometres. Seven new concessions and extensions, together 77.03 kilometres, accorded during the present year, brings up the total number of lines to 88, and the total length to 1,900.92 kilometres (1,181 miles). Of this number, 73 lines, 1,549.6 kilometres (962 miles) long, are laid to the gauge of one metre (3 ft. 3 $\frac{3}{8}$ in.); and 11 lines, 325.27 kilometres (213 miles) long, to the gauge of 1.067 metre (3 ft. 5 $\frac{3}{8}$ in.), which is that of

the Dutch Vicinal Railways, so as to permit of through working into Holland, while the remaining four lines are laid to the standard gauge, because forming actual junctions with normal lines.

Out of the above number, 71 lines are already opened for traffic, 69 of them being worked by steam locomotives and one only by horses, while on another line locomotives have been superseded by electric haulage on the trolley system, which will also be adopted on the network of the centre district, also on the Charleroi urban lines. Besides the 88 lines conceded to the Société Nationale before its formation, seven others were conceded to independent companies; and this brings the number of light or economical lines up to 95, together 1,970 kilometres (1,224 miles) long, and constituting 42.7 per cent. of the normal standard gauge lines, the total length of which is 4,605 kilometres (2,861 miles).

The length of principal line, *i.e.*, not including sidings or crossings, opened at the end of last year was 1,469.691 kilometres (913 miles), of which 1,043.552 kilometres were laid along roads not widened, 82.828 along widened roads, and only 343.311 kilometres on land taken for the purpose. Last year three new points of union, not actual junctions, but comprising exchange stations with standard-gauge lines, brought up the total number to 77, including 50 with the Belgian State Railways. During the same period 23 new private sidings brought up their total number to 159, including 113 to works and 45 to farms. At the end of last year the total amount of contracts made for laying and stocking the various lines amounted to 71,238,931 frs. (£2,849,557).

Last year's total receipts, *viz.*, those for all the lines and from all sources, amounted to 7,055,591 frs. 25 c., and the expenses to 4,742,297 frs. 23 c., showing the mean coefficient of working to be 67.21 per cent., against 68.43 per cent. in 1896, while the receipts during the beginning of the present year show a tendency to increase in still greater ratio. Of the eight lines which carry passengers, and not goods, there was an increase in the number of passengers, and in two a diminution. Of the 56 lines carrying both goods and passengers, in 29 there was an increase in the receipts from both sources; in 6 there was increase from passengers and diminution from goods, with increase on the whole; in 9 there was diminution of passengers and increase of goods, with increase on the whole, and in 10 lines there was just the contrary, while in two lines only was there increase of goods with diminution in passengers and also on the whole working. This shows an increase in the total receipts for 44 lines and diminution for 12 others. As to 10 of these, this is accounted for by the unusual dryness of last autumn, and depression in the beetroot sugar trade, while in some cases the previous year's receipts were swelled by unusual causes which did not operate last year.

In 1891, the trains ran over 3,948,691 kilometres

* See *Journal* of June 21, 1895, July 3, 1896, and June 18, 1897.

(2,453,645 miles), and in 1897 over 7,118,197·65 kilometres (4,423,127 miles), showing an increase of 44·53 per cent.; but, notwithstanding this great increase, the number of fatal accidents has not increased appreciably. Last year the number of persons killed was 30, of whom only two were *employés*, and three passengers who attempted to enter or leave a train in motion, the remainder being those who attempted to cross the line in the front of a train, or were deaf, drunk, or evidently intended to commit suicide.

The general or administrative expenses, which in 1891 corresponded with 3·808 per cent. of the cost incurred in making and stocking the lines, became reduced to 3·764 per cent. last year. Out of the 70 lines in operation on 31st December, 1897, an improved financial condition was shown by 50; and 47 paid a higher dividend last year than in 1896, while the accounts of three others were balanced by slight profits, as against losses on previous year's working. The total loss in working since the Society began operations in 1885 was accordingly reduced from 75,472 frs. 59 c. at the end of 1896, to 62,166 frs. 92c. (£2,486 13s. 6½d.) at the end of last year, while the reserve fund, intended to partly meet these losses, was increased from 535,831 frs. 49 c., at the end of 1896, to 702,204 frs. 86 c. (£28,088 3s. 11d.) at the end of last year. The sum of the individual reserve fund of the various lines increased respectively from 357,220 frs. 83 c. to 468,136 frs. 36 c. (£18,725 9s. 1d.). During the last two years not a single line has been worked at a loss; and of the 65 lines that have been worked at least for a whole year, 30 yield a dividend higher than that guaranteed, 7 a dividend higher than 3 per cent., and 8 others more than 2·5 per cent. The mean dividend has indeed increased with remarkable regularity from 2·65 per cent. in 1890, to 2·75 per cent., 2·76 per cent., 2·8 per cent., 2·9 per cent., 2·98 per cent., and 3·08 per cent., until it attained 3·15 per cent. last year.

LEIPSIK COMMERCIAL HIGH SCHOOL.

The New Commercial High School (*Handels-hochschule*) which was opened on the 26th April last, is thus described by her Majesty's Consul at Stettin in a report received by the Foreign Office:—

"The opening of the first German *Handels-hochschule* at Leipzig is an occurrence that must be looked upon by merchants and those connected with the vast commerce of the United Kingdom as an object-lesson of very serious import. It is an event that is hailed all over Germany by educated persons with the keenest interest and intense expectation as a great advance in the commercial education of the Empire. The choice of Leipzig as the centre of Germany and the seat of an ancient and flourishing commerce, which during the last 20 years has developed to an enormous extent, and as also the seat of one of the oldest and most celebrated of the Universities, has been much approved.

"The *Handels-hochschule* has wide aims; it does not confine itself to clerks or young men interested in business, but opens its classes and lectures to merchants who are seeking for a higher commercial education to fit them for the duties which may some day devolve upon them as heads of large industrial and commercial firms; also to those who may be destined to represent the interests of German trade in foreign lands, such as Consuls, &c., in fact, to all who have a desire to increase their knowledge in general commercial accomplishments or on any special industrial branch. It also is intended to give instruction to lawyers and retired officers of the Army and Navy in mercantile affairs, as for instance, the laws and practice of insurance. Chemists who are employed as apothecaries in large druggists' stores or in chemical works, will also find their classes and educational lectures in this comprehensive establishment.

"Its connection with the University of Leipsic, the second in Germany, with the collaboration of its leading professors, appears to give evident and unmistakable proof that the new institution will be carried on successfully, and that the excellent design of giving a deeper and better commercial education in all its branches may be fully realised.

"The Leipsic Chamber of Commerce has given a financial guarantee for the working of the school, but under a subvention from the Saxon Government and a large yearly contribution from the City of Leipsic towards the expenses. I believe that seldom has anything more desirable and advantageous towards the promotion of commercial education been evolved than this new *Handels-hochschule* at the venerable University of Leipsic."

Correspondence.

PARLIAMENTARY RETURN OF SECONDARY AND OTHER SCHOOLS.

I would not have troubled you with a letter upon Mr. Brereton's notes on this Return had it not been for the final paragraph, which has nothing to do with the Return. "Technical" schools as such are not excluded from the Return. All the "local authority" schools in that Return, and three-quarters of the "endowed" schools, have more than two-thirds of that work "technical" within the meaning of the Technical Instruction Acts, and are subsidised as such by the local authorities or by the Science and Art Department, all of whose work is within the scope of those Acts. The schools which are excluded are technical evening schools and technological (or tertiary) day schools. The opinion of the Antwerp Conference, and of all educationalists who are not trade unionists, is that it is the technological subjects (commercial as well as industrial) which should be relegated to the tertiary stage, not the

technical subjects within the meaning of most of the work of the Science and Art Department, and of quite half of the work under the Technical Instruction Act. There is no argument here for severing that Department and those authorities under that Act from the secondary schools. In no secondary school in England established by a local authority is there given a "disconnected smattering in general and technical subjects."

H. MACAN.

Obituary.

JOHN PHILIPSON.—Mr. John Philipson, a member of the Society of Arts since 1882, died at his residence in Newcastle, on Friday, 24th June, after an attack of influenza. Mr. Philipson was born at Newcastle on October 19th, 1832, and was educated at Dr. Collingwood Bruce's school. He subsequently was apprenticed to his father, head of the firm of Atkinson and Philipson, coach builders, which was founded in 1794. He was greatly interested in the cause of technical education, and nearly thirty years ago he instituted technical classes in his own works. He was the inventor of improvements in carriage construction, and the author of text-books on "Coach Bodymaking," "Harness," and "The Art and Craft of Coach-building." In 1895, he was President of the Institute of British Carriage Manufacturers, and a member of several other societies. He was a contributor to the *Journal of the Society of Arts*.

SIR JOHN SCOTT, K.C.M.G.—Sir John Scott, who died at his residence, Southhome, Chislehurst, on Wednesday, 29th ult., had been a member of the Society of Arts since 1875. He was born in 1814, and entered the public service in 1840. Three years later he was appointed secretary to the Royal Commission under the Ashburton treaty to define and mark on the spot the north-eastern boundary between Canada and the United States. His next appointment was as Surveyor-General, member of the Legislative Council, and senior magistrate of the new settlement of Labuan, in the eastern archipelago. In 1849 he became Acting Lieutenant-Governor and Treasurer, and in the next year succeeded to the Governorship of the colony. Six years later he was transferred to the Governorship of Natal, where he remained until 1865. He was appointed Governor of British Guiana in December, 1868, and resigned at the end of 1873, being created K.C.M.G. in the following year.

General Notes.

BRUSSELS ART CONGRESS.—Information has been received by the Science and Art Department, through

the Foreign Office, of a Congress of Public Art which will be held at Brussels from the 24th to the 28th of September next. This first International Congress on Art has been organised by L'Œuvre Nationale Belge. The subjects to be discussed at this Congress will fall under the three following sections:—Public art (1) from the legislative point of view; (2) from the social point of view; and (3) from the technical point of view. The address of the general secretariat of the Congress is Hotel Ravenstein, Bruxelles.

CONSUMPTION OF COFFEE.—The following Table taken from the *Economista*, and quoted in the *Board of Trade Journal*, shows the annual consumption of coffee for the last five years in the United States and the principal countries of Europe:—

	Europe. Tons.		U. S. A. Tons.
1893	271,498	....	248,117
1894	272,191	....	258,822
1895	277,400	....	260,880
1896	291,150	....	267,880
1897	305,150	....	318,170

As will be seen from the above, the consumption of coffee in the United States in 1897 exceeded that of the whole of Europe. The European countries which consumed the most coffee are Germany (136,390 tons) and France (77,310 tons). The United Kingdom consumed only 12,420 tons, and Italy 12,500 tons.

FRENCH ECONOMIC PROGRESS SINCE 1870.—According to the *Bulletin de la Société Géographie Commerciale*, since the end of 1869 the postal traffic has nearly tripled; the telegraphic network is about nine times greater; the tonnage of the railways has doubled; the number of travellers has tripled; the receipt of the railways, which were £27,840,000, have increased more than £20,000,000; interior navigation has doubled; the production and consumption of coal have increased from £840,000 to £1,520,000. The production of cast-iron has advanced 33 per cent. The discounts at the Bank of France have risen from £265,000,000 to £345,000,000. Personal property has increased enormously. Deposits in the savings banks which at the end of 1869 were £30,000,000, now exceed £160,000,000. The number of accounts open was never so large. The deposit of funds in banks and credit societies exceeds £60,000,000. France, since the war, has been able to pay £1,280,000,000 for the public debt and donations; £1,000,000,000 for the army, navy, and colonies; £80,000,000 for public instruction, and £200,000,000 for public works, and this does not include the expenditures of private companies. The £480,000,000 which the war of 1870 and the Commune of 1871 cost have been paid. No country has given such marvellous proofs of activity and of progress, notwithstanding the heavy taxes.

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FRIDAY, JULY 15, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.

CHAIRMANSHIP OF COUNCIL.

On Monday, 11th inst., at their first meeting after the annual election, the Council elected Sir John Wolfe-Barry, K.C.B., F.R.S., as Chairman for the ensuing year.

Sir Westby Perceval, K.C.M.G., and Mr. Alexander Siemens were elected to fill vacancies on the Council, caused by the non-acceptance of office on the part of Earl Grey and Sir George Chubb.

Proceedings of the Society.

CANTOR LECTURES.

THE THERMO-CHEMISTRY OF THE BESSEMER PROCESS.

BY PROF. NOEL HARTLEY, F.R.S.

Lecture II.—Delivered March 21, 1898.

It is, I feel sure, with much regret that you have learned that the great inventor of the process which forms the subject of this course of lectures, has passed away from amongst us since our last meeting a week ago. Sir Henry Bessemer has been a great personality, and it is with a sense of gratification that we become aware not only of the honours which have been conferred upon him, but of the pecuniary reward which he received, such as not often falls to the lot of inventors, whatever may be their ability and the merits of their inventions. In the course of twenty minutes it has been said that he converted material at the time worth about £80, into that which was valued at £1,200; that his genius produced a metal which made the building of the Forth Bridge not only a possibility, but an actual fact; furthermore, he gave the railroads of the world, steel instead of wrought iron for their rails. The reward to himself and family, as he modestly expressed it, consisted in re-

ceiving more than 1,600,000 of those beautiful little medals which her Majesty issues from the Royal Mint.

Let me now draw attention to the curves (Fig. 10, p. 722) showing the course of chemical change in the Thomas-Gilchrist "basic" process, as carried out at Longwy in the Meurthe and Moselle district.* The metal contains carbon 2·8 per cent., phosphorus 2·06, manganese 1·5, silicon 0·63, and sulphur 0·048. The lime added to the charge is 17·5 per cent., and the final addition is 0·5 per cent. of ferromanganese, containing 63 per cent. of manganese.

The first point to be noted is that from the commencement of the blow until the drop of the flame is eleven-and-a-quarter minutes; secondly, that the entire quantity of silicon, which is small in amount, is removed in two-and-one-fifth minutes. Note, that during this time the curves show the manganese is being oxidised at the same rate as the silicon, to form manganese silicate. Remark, also, that the carbon is being oxidised at the same rate, down to the close of the first three minutes. These facts are indications that the compounds manganese silicide and manganese carbide are the substances under oxidation. From the third to the fifth minute the manganese and carbon go together, but that subsequently the carbon is oxidised with much greater rapidity between the fifth and ninth minutes, the curve making a very steep descent. As long as carbon and manganese are present the phosphorus undergoes very little change, so that up to eleven-and-a-quarter minutes it has decreased only by one-half. But now the "after-blow" commences, and the removal of the phosphorus proceeds at a rate more than five times as rapid, until it is nearly all removed. The compound present you will recollect is ferrous-phosphide. Note, that the sulphur remains nearly the same all through, being represented by what is almost a horizontal straight line, the per-centage varying from 0·048 to 0·047. The compound is ferrous sulphide. On the addition of ferro-manganese there is a rise of manganese visible as a matter of course to 0·25 per cent., and a slight increase in carbon. As 0·71 per cent of carbon burns along with 0·9 per cent. of manganese, these numbers indicate the compound MnC_2 . And as 0·6 per cent. manganese burns at the same time as 0·525 per cent. of silicon, a silicate of the formula MnO_2SiO_2 would be the most probable product, which by the action of the lime would become more basic. The course of change is

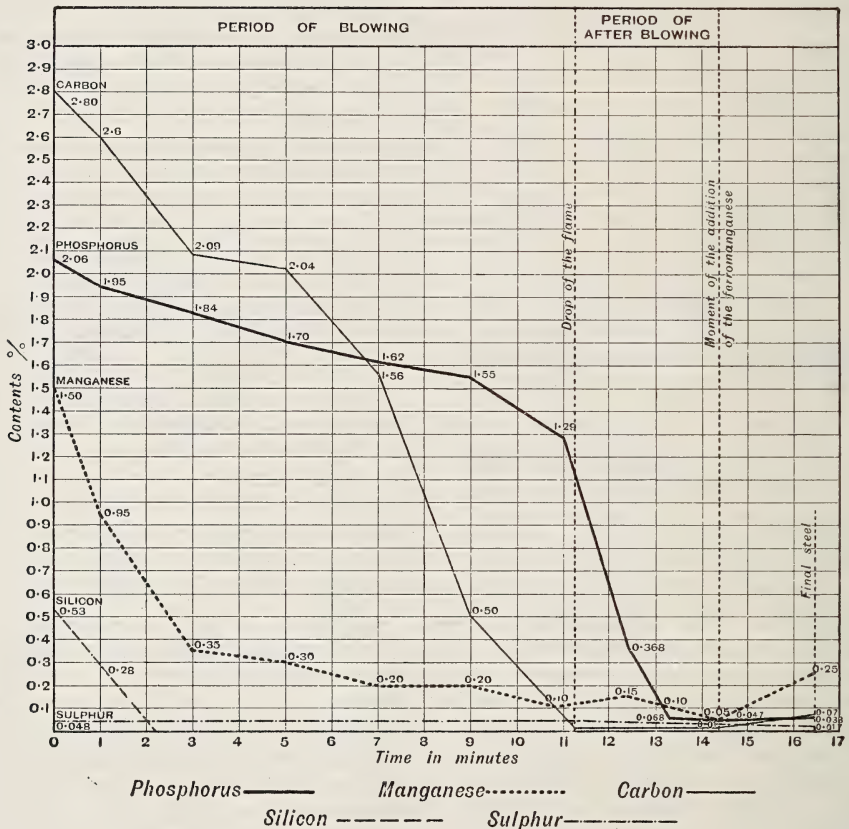
* From the "Journal of the Iron and Steel Institute."

accounted for later by a reference to thermo-chemical equations.

The different periods of the "blow" and the visible effect in each period is best described to you by a series of photographs taken by Mr. Ramage and myself at the North Eastern Steel Company's Works at Middlesborough. (See Figs. 11, 12, 13, 14.) There are four converters, each charge being 12 tons of metal and 2 tons of lime. In Fig. 11, a stream of molten metal is seen passing from the gallery above

other photographs were thrown on the screen, one showing the "boil" further advanced, the flame being thin and less copious, and the other at a still further stage when it had diminished in size, and an out-burst of slag and a shower of falling sparks was shown.] Fig. 13 shows the over-blow with the flame burning not outside, but within the vessel, and a vast cloud of fume arising beyond the apex. [Another photograph was shown with the over-blow still further advanced after

FIG. 10.



into the mouth of the vessel which is turned down so that its hollow axis is horizontal. At the further end of the building steam is rising from some operation not connected with the "blow," and to the right of the steam is the flame from the mouth of the converter. In Fig. 12 to the left is seen the flame of spiegel-eisen, which has just been added to a finished charge, and beyond is the long flame of a charge in the period called the "boil." Fume is seen rising from the top of the flame. [Two

the metal had been tested for phosphorus, and the blow resumed.] Fig. 14 shows the flame when the vessel is being turned down at the finish. You will understand the copious fume is caused by the burning of the metal, in the ordinary "acid" this burning does not take place to the same extent.

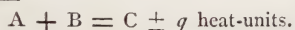
In 1888 I worked out a number of thermo-chemical equations from the then existing data, which explained various metallurgical operations employed in the reduction of metals

from their ores, solely for my own information. In 1890 several of these were communicated to the Royal Dublin Society in a paper, entitled, "A Study in Thermo-Chemistry," which is published in the "Scientific Proceedings of the Society" for 1891. Some alterations have been made in the data published since that time, which refer to the same chemical changes, but considering the number of years during which thermo-chemistry has been investigated by Faure and Silbermann, Andrews, Berthelot, and Julius Thomsen, I think the principles of the subject have received scarcely adequate attention. This may be partly owing to the too restricted view which prevails at present, namely, that chemistry deals with changes and interchanges of materials or matter, while the physical conditions of matter and the energy associated with the atoms are either ignored or referred to in vague terms, such as *chemical affinity* and *chemical energy*, but not by the thermal constants (numerical values) which in a large number of cases have been determined. These constants can be very profitably employed in explaining not only ordinary reactions but also many which are obscure.

EXPLANATION OF THE TERMS USED.

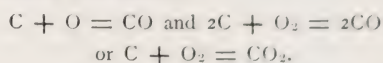
As a rule there is associated with the atoms or the elements a certain amount of energy which may be measured in terms of heat.

When one substance A combines with another B to form a third substance C, there is a certain amount of energy lost or gained.* This may be referred to as heat disturbance, since energy can be measured in terms of heat. The change may be put in the form of an equation—



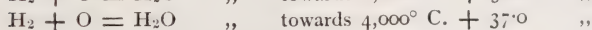
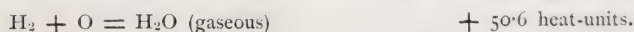
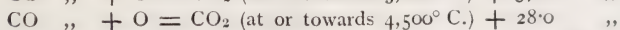
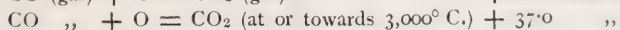
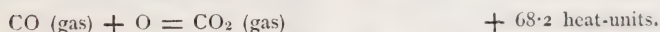
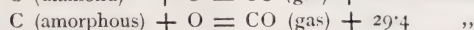
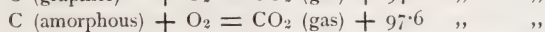
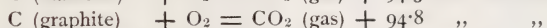
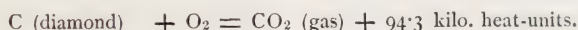
Now, it must be understood that when A and

B combine, as, for instance, when carbon combines with oxygen, they do not form A B, because the energy associated with A and B is not the exact quantity associated with the third substance C. This latter C differs from $A + B$ by $\pm q$ heat-units. In other words to be more explicit, in soda there is, strictly speaking, no sodium, in water there is neither hydrogen nor oxygen, in carbon monoxide there is neither carbon nor oxygen. The representation in the ordinary equations here following, deals only with the quantity of matter in the atoms, and not with the energy associated with them:—



The expression is in each case somewhat incomplete, because in the act of union some of the energy associated with these atoms is dissipated, and before they can be again separated, it must be supplied to the material out of which they are to be evolved. Thermo-chemical equations are most conveniently expressed in gramme atoms and kilogramme heat-units. The French writers use the term *calorie* for a heat-unit, and a kilogramme heat-unit would appear as a large *calorie*.

A gramme atom is an atomic weight expressed in grammes. A heat-unit, used in this connection, is the quantity of heat required to raise 1 kilogramme of water 1°C . The energy associated with a gramme atom is stated in kilogramme heat-units. Thus a gramme atom of carbon is represented by C, of hydrogen by H, and of Oxygen by O, or 12 grammes, 1 gramme, and 16 grammes respectively. The combination of carbon with oxygen to form carbon dioxide, is stated in the following, the physical state of the carbon being written after the symbol:—†



* For information on this subject, see "Ostwald's Chemistry," translated by Dr. Walker; "Thermo-Chemistry," by Pattison Muir; "Chimie Élémentaire," by A. Ditte; also Richter's "Chemistry," translated by Smith; and "Etudes sur les Metaux," by A. Ditte.
† Berthelot. "Lois et Données," 1897.

Twelve grammes weight of diamond combine with 32 grammes of oxygen to form 44 grammes of carbon dioxide, with an evolution of heat sufficient to raise 94.3 kilogrammes of water from zero to 1° C.

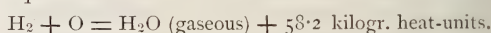
The physical state of the reacting substances must be taken into account, and likewise the physical state, whether solid, liquid, or gaseous of the products. This is generally stated by a word within brackets, as in the examples quoted.

A reaction in which energy is convertible into and manifested by evolution of heat is termed exothermic; a reaction in which energy is absorbed, this energy being measurable in terms of heat, is called endothermic.

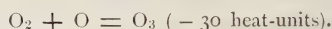
In the former the compound formed differs from its constituent atoms by something less than the energy associated with them. In the latter case the compound differs by containing more energy than its constituents. But in the former reaction the heat disturbance is positive, and is denoted by a plus sign (+); in the

latter it is a negative quantity, and is indicated by a minus sign (−). In the formation of the compound this energy is external to the system, and must be supplied to it. The external energy must be added to that of the constituents of the compound.

For example, when hydrogen combines with oxygen to form water, much heat is evolved, the amount of which has been exactly ascertained, and this is explained by the following equation:—



But when oxygen combines with oxygen to form ozone there is much energy absorbed, thus:—



The energy of O_2 or 32 parts plus that of O or 16 parts is insufficient to produce the energy of O_3 by an amount measured by 30 kilogramme heat-units. This must be supplied by some means or other, or the substance ozone will not be formed.

HEAT OF FORMATION OF COMPOUNDS.

(Berthelot. "Lois et Données," 1897, vol. ii.)

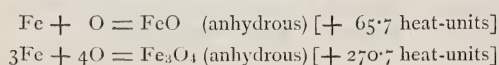
Heat-units. Thermo-chemical Equations. I.—Simple Combinations.

SiO_2	+ 179.6	
Mn_3C	+ 9.9	$3 \text{ Mn} + \text{C} = \text{Mn}_3\text{C. [+ 9.9 heat-units].}$
MnO (anhydrous)	+ 90.9	$\text{Mn}_3\text{C} + 3 \text{ O}_2 = \text{Mn}_3\text{O}_4 + \text{CO}_2 \text{ [+ 412.4 heat-units].}$
$\text{Mn}_3\text{O}_4 \text{ (anhydrous)}$	+ 328.0	$\text{SiO}_2 + \text{MnO (anhydrous)} = \text{MnSiO}_3 \text{ [+ 5.4 heat-units].}$
$3 \text{ MnO} + \text{O (Mn}_3\text{O}_4)$	+ 55.2	
$\text{MnO} + \text{O (MnO}_2)$	+ 34.2	$2 \text{ Fe} + 3 \text{ O} = \text{Fe}_2\text{O}_3 \text{ (anhydrous) } 400^\circ \text{C. [+ 197.7 heat-units] or } 65.9 \times 3$
$\text{Mn}_3\text{O}_4 + \text{O (3 MnO}_2)$	+ 48.0	
$\text{Mn}_3 \text{ (precipitated)}$	+ 45.6	$2 \text{ Fe} + 3 \text{ O} = \text{Fe}_2\text{O}_3 \text{ (anhydrous) } 1,000^\circ \text{C. [+ 195.6 heat-units] or } 65.2 \times 3$
CaS (solid)	+ 90.8	
CaO (anhydrous)	+ 131.5	
$\text{Ca}_3\text{P}_2\text{O}_8$	+ 913.6	$\text{Fe}_2\text{O}_3 \text{ at } 400^\circ \text{ changed to } \text{Fe}_2\text{O}_3 \text{ at } 1,000^\circ \text{ [+ 2.1 heat-units].}$
$\text{CaSiO}_3 \text{ (calcined)}$	+ 344.4	
FeO (anhydrous)	+ 65.7	$\text{Si (amorphous)} + \text{O}_2 = \text{SiO}_2 \text{ [+ 179.6 heat-units].}$
$\text{Fe}_3\text{O}_4 \text{ (anhydrous)}$	+ 270.7	$\text{Si (crystals)} + \text{O}_2 = \text{SiO}_2 \text{ [+ 184.5 heat-units].}$
$\text{FeSiO}_3 \text{ (calcined)}$	+ 254.6	
$\text{SiO}_2 + \text{FeO (anhydrous)}$	+ 9.3	$\text{SiO}_2 \text{ (crystallised)} + \text{CaO} = \text{CaSiO}_2 \text{ [+ 33.1 heat-units].}$
FeS (hydrated)	+ 24.0	
$\text{SO}_2 \text{ (gas)}$	+ 69.2	

In writing thermo-chemical calculations it is necessary to know the heat of formation of the compounds dealt with, and many of those numbers which may have to be quoted are given in the accompanying Table.

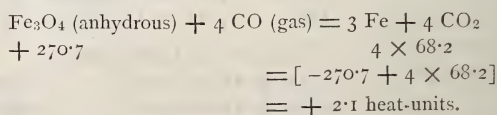
In working out equations, these figures are used in the following manner:—

A. Simple combinations. Oxidation,



In both these cases heat is evolved, and this is denoted by the sign + of an exothermic action.

B. Reduction.



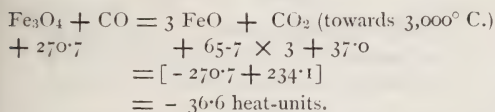
In this equation we have heat absorbed in the reduction of Fe_3O_4 to 3 Fe, and heat evolved by the conversion of CO into CO_2 . The total effect + 2.1 is obtained by subtraction of

270.7 on one side of the equation, from 272.8 (68.2×4) on the other.

$$+ 272.8 - 270.7 = + 2.1 \text{ heat-units.}$$

The sign + denotes that the action is exothermic.

At high temperatures, as for instance towards $3,000^{\circ}\text{C}$., carbon monoxide evolves much less heat in burning to carbon dioxide, namely, +37.0 instead of +68.2 heat-units, so that this reducing action may not take place. This is explained by the following equation:—



This action is endothermic, as indicated by the — sign.

For the sake of simplicity, where the words “heat-units” are omitted, they must be understood in this discourse to be kilogramme heat-units.

THE CONDITIONS UNDER WHICH CHEMICAL CHANGE TAKES PLACE IN METALLURGICAL OPERATIONS.

All chemical reactions take place only within certain limits of temperature. At low temperatures chemical combinations cannot take place, even the most energetic actions, as demonstrated recently by Professor Dewar; at very high temperatures most chemical combinations cannot exist. There are, however, some chemical compounds which are formed only at very high temperatures. Cyanogen, acetylene, and ferrous carbide are examples of such endothermic combinations. The only elements having apparently no energy associated with their atoms, so far as we have been able to discover, are argon and helium; if they form any combinations at all with other elements, these must be substances of an endothermic character. Prof. Julius Thomsen and Prof. Ramsay have examined two minerals which are endothermic; when gently heated they glow red-hot, and at the same time evolve helium.

Smelting operations are conducted either in reverberatory furnaces or some form of blast furnace. The fuel is first burnt to carbon dioxide (CO_2), and this gas is converted into carbon monoxide (CO) by contact with more red-hot fuel.

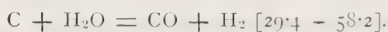
In either case the following functions are performed:—

- (a). Initiation of the reducing process by heating the ore, that is, by raising it to a suitable temperature.
- (b). Reduction of the ore by carbon monoxide gas (CO).
- (c). In certain cases, in which the reducing process consists of feebly exothermic reactions, to maintain the reducing process by the continuous supply of extraneous heat.

Now in the Bessemer process there are both oxidations and reductions. (1.) Oxidation of the non-metallic elements purposely carried out, or of compounds of iron with non-metallic elements. (2.) Oxidation of iron incidental to the process of oxidising its compounds. (3.) Reduction of oxidised metallic products.

The reductions may be similar to those accomplished in furnace operations, namely: (1.) Reduction accomplished by means of furnace gases. (2.) Reduction by carbon. (3.) Reduction by another metal; in steel manufacture this metal is manganese or one of its compounds as manganese carbide.

Furnace gases, which operate in reducing processes, consist chiefly of carbon monoxide (CO), and some hydrogen. The production of the so-called “water gas,” which is of this nature, can take place only at high temperatures, because it involves a loss of heat—



This action is endothermic in a high degree. The heat evolved by the formation of water amounts to 58.2 units, and that of carbon monoxide to only 29.4 units, so it follows that to bring about the oxidation of carbon by the deoxidation of water, 28.8 heat-units must be continuously supplied to the two substances. In other words, to oxidise carbon by means of water, a very high temperature is one of the conditions necessary before the process can be initiated, and this high temperature must be maintained, or the production of water-gas will cease. It will thus appear (a) that the economical production of water-gas cannot have been otherwise than illusory; (b) that when Bessemer employed steam instead of air the process was a failure, because the metal cooled and solidified. The reducing action of carbon monoxide will be seen by equations 1 and 3 to be superior to that of hydrogen by 10.0 heat-units, inasmuch as the former, at ordinary furnace temperatures, evolves 68.2 heat-units for every atom of oxygen removed from an oxide, while the latter evolves 58.2 heat-units, there is therefore a gain of 10 units

by using carbon monoxide. Consequently, it is necessary to consider the action of carbon monoxide and of carbon in smelting processes, but not necessarily that of hydrogen.

All those metallic oxides the heat of formation of which is less than 69 heat-units are capable of reduction in a reverberatory furnace, and therefore by carbon or by carbonic oxide in a Bessemer vessel, should they be contained in the crude metal. These reactions of carbon, oxygen, and water are of fundamental importance in dealing with the Bessemer process.* Besides the investigations of Professor Åkermann, Professor Jordan, Kupelwieser, Snelus, and others, extensive work on the subject has been published by Sir Isaac Lowthian Bell, chiefly in relation to the thermo-chemistry of the blast furnace ("Manufacture of Iron and Steel"). M. Pourcel has more recently drawn attention to the subject,† and Professor Ledebur points out the importance of the questions which may be referred to thermo-chemistry.‡ The latter is of opinion that before accuracy can be attained in the calculations it is necessary that we should determine definitely, first, in what state of combination the various substances exist which occur in a bath of molten metal; secondly, what are the real products of combustion of such impurities.

In 1895, I had the honour to contribute a paper to the "Philosophical Transactions of the Royal Society," and also to the "Journal of the Iron and Steel Institute," on the thermo-chemistry of the Bessemer process, dealing, however, chiefly with the temperature of the metal, the flame, and the heat evolved. A series of calculations was made which, on consideration, have been modified by accepting fresh data, but these later calculations have been in some measure anticipated by Professor Ponthière. As a basis of his calculations he assumes that the metal he is dealing with is a white cast-iron suitable for treatment by the basic Bessemer process, and that it has the following composition:—Si 1·0 per cent., Mn 1·5 per cent., C 3·5 per cent., P 1·4 per cent., S 0·01 per cent., and Fe 92·59 per cent.

In the substance termed iron we have a very complex mixture: manganese is combined with silicon, carbon, phosphorus, and sulphur entirely, none of it existing in the

free metallic state. In other words we have, as a rule, no metallic manganese alloyed with the iron.

The reason for assuming this as fact is based on the stability of the compounds at high temperature, owing the great heat of formation of manganese compounds into which the above-named elements enter.*

Troost and Hautefeuille made a calorimetric investigation of pig iron, which led to the following results†:—

<i>Ferrous Carbide.</i>		
Gramme.		Heat-units.
1 of iron chloridised evolves.....		0·827
1 of iron in 1·040 gr. of grey pig....		0·879
1 of iron in 1·041 gr. of white pig ..		0·896

The grey and the white pig irons contain 3·8 and 3·9 per cent. of carbon respectively.

The above figures show that the formation of ferrous carbides takes place with heat absorption, and it is well known that ferrous carbide in cast iron decomposes when the metal is cooled gradually, which is quite in accordance with its being an endothermic compound formed only at a high temperature. The fact that the same molten metal will produce grey pig iron when cooled slowly, by dissociation of the carbon and the iron, and white pig iron when cooled rapidly, in which the carbon is present as a ferrous carbide, because it has not had time to dissociate, is readily understood upon studying the above statement.

<i>Manganese Carbide.</i>		
Gramme.		Heat-units.
1 of manganese carbide containing 4·8 per cent. of carbon evolves....		1·180
1 of manganese carbide containing 5·8 per cent. of carbon evolves....		1·010
1 of manganese carbide containing 6·7 per cent. of carbon evolves....		0·260

Hence the formation of manganese carbide takes place with heat evolution. The carbide with the formula Mn_3C has very great stability.

<i>Ferrous Silicide.</i>			
	Silicon. Per cent.	Carbon. Per cent.	Heat-units.
Ferrous silicide with 3·5 and 0·6 evolves			0·970
" " " 7·0 " 0·4 "			1·050
" " " 12·0 " 0·4 "			1·185
" " " 14·0 " 0·4 "			1·270

* "Chemistry Applied to the Arts and Manufactures." Edited by C. W. Vincent. Mackenzie, Glasgow.

+ "Jour. Iron and Steel Inst.," vol. 1889, p. 152.

‡ "Stahl und Eisen," vol. ix. pp. 712-717.

* "Annales de Chimie et de Physique," 5th series, vol. ix., 1876. Troost and Hautefeuille.

† "Etudes sur les Metaux," par A. Ditte, vol. i. pp. 143-48, 1891.



FIG. 11.—CHARGING A CONVERTER.



FIG. 12.—BLAZE FROM SPIEGEL-EISEN AND LONG FLAME FROM A CONVERTER.



FIG. 13.—FUME AND FLAME, THE EFFECT OF THE OVERBLOW.



FIG. 14.—CONVERTER BEING TURNED DOWN AT THE FINISH.

Heat evolved by the Ferrous Silicide.	Heat evolved by the separate Elements.	Difference.
Units.	Units.	Units.
0·970	0·970	0·000
1·050	1·125	0·075
1·185	1·395	0·110
1·270	1·425	0·155

The formation of iron silicide takes place therefore with *heat absorption*.

Of the known carbides of manganese Mn_3C , MnC_2 and MnC_3 , that which is combined with the largest proportion of carbon, namely, MnC_2 is the one assumed to be present, together with the known compounds Mn_2Si_2 , MnS , and Mn_3P_2 . It must not be overlooked that Mn_3C may be a more stable compound than MnC_2 , at high temperatures, such as that of melted cast iron.

The ferrous compounds are probably those containing the largest proportion of metal, as

Manganese Silicide.

Gramme.	Silicon. Per cent.	Carbon. Per cent.	Units of Heat evolved.	Heat evolved by separate Elements. Units.	Difference.
I Manganese silicide with	8	and	I .. 1·330	.. 2·160	.. 0·830
„ „ „ „	12	„	I .. 1·250	.. 2·280	.. 1·030

The formation of manganese silicide takes place with the *evolution of a considerable quantity of heat*, and the compound formed is very stable.

To sum up, iron carbides and silicides are endothermic, and at low temperatures unstable. Manganese carbide and silicide, on the other hand, are strongly exothermic, and consequently very stable compounds. Both iron and manganese phosphides are very stable, as they evolve a large amount of heat in their formation, and are therefore strongly exothermic substances.

But there is another fact of great significance which supports this view, namely, that manganese and carbon oxidise together during the blow, and so do manganese and silicon, especially during the slag-forming period, but the carbon oxidises more rapidly during the boil. This is seen in the curves of the acid "blow" drawn from analyses quoted by Brunner, the manganese being 3 to 6 per cent. Also in the curves of the basic "blow" carried out at Longwy. Such regularity in oxidation could scarcely take place if the manganese, carbon, and silicon were in the free state.

It has been shown by Sir Frederick Abel and Mr. Deering that a perfectly definite carbide exists in steel with the composition Fe_3C ; this has been recognised by MM. Osmond and Werth. More recently M. Moissan has obtained a definite ferrous carbide Fe_3C and manganese carbide Mn_3C .* A ferrous silicide Fe_2Si which he discovered contains from 18 per cent. to 20 per cent. of silicon.

iron is in excess. These compounds are Fe_3C , $FeSi$, Fe_3P , and FeS . Towards this conclusion in the case of $FeSi$, we have a fact to support it in the analysis of a slag from the North Chicago Steel Works, containing MnO 2·68, FeO 46·20, and SiO_2 40·30 per cent. This gives us a formula $FeSiO_3 \cdot MnSiO_2$. I have calculated this formula from the numbers given in the paper by Mr. H. M. Howe, A.M., S.B., of Boston, U.S.A.*

Assuming that two-thirds of the manganese is combined with carbon and one-third with silicon, in accordance with the difference in the heat of formation of these substances we have, according to the assumption of Prof. Pontière, the metal constituted as follows :—

CONSTITUTION OF A PIG IRON OR BLAST FURNACE METAL.

		Per cent.	Per cent.
Manganese Carbide..	MnC_2	{ Mn 1·00 C 0·40 }	1·40
Manganese Silicide..	Mn_2Si_2	{ Mn 0·50 Si 0·14 }	0·64
Manganese Phosphide	Mn_3P_2		traces.
Manganese Sulphide.	MnS		traces.
Ferrous Carbide	Fe_3C	{ Fe 43·40 C 3·10 }	46·5
Ferrous Silicide	$FeSi$	{ Fe 1·72 Si 0·86 }	2·58
Ferrous Phosphide ..	Fe_3P	{ Fe 7·58 P 1·40 }	8·98
Ferrous Sulphide....	FeS		traces.
Metallic Iron	Fe		39·9
Total.....			100·00

Iron evolves but little heat when combining with silicon, carbon, and sulphur, and in fact, when allowed to cool slowly, silicon and carbon separate from the iron by dissociation, while

* "Le Four Electrique," 1897, Paris.

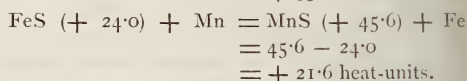
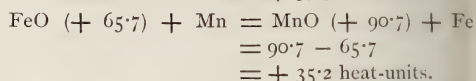
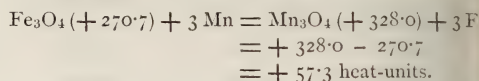
* "Jour. Iron and Steel Inst.," 1890, No. 2.

rapid cooling prevents dissociation. But as the combination of iron with phosphorus approaches in thermal value that of manganese, the phosphorus of the metal is divided between the manganese and iron approximately in proportion to their masses. In such a case as this with Mn 1·5 per cent. and Fe 92·59 per cent., the phosphorus is present almost entirely as the ferrous phosphide, PFe_3 , while the excess of silicon, carbon, and sulphur beyond that which is combined with the manganese is united to the iron.*

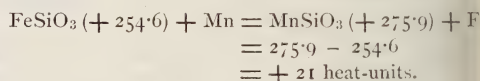
There are some fundamental facts which may be made clear by thermo-chemical equations.

(a) Manganese can act as a reducing agent to compounds of iron with oxygen and sulphur, because its action will result in an evolution of heat.

Thus:—



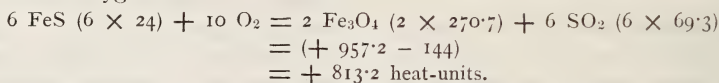
It may also act upon ferrous silicates.



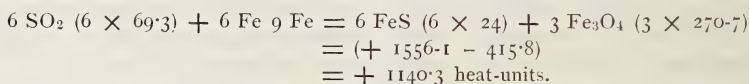
(b) The effect of mass on chemical change is sometimes to cause a chemical reaction to be reversed.

The Effect of the "Blow" on Ferrous Sulphide.

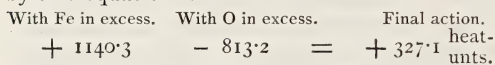
With excess of oxygen:—



With excess of iron:—

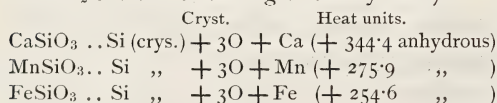


The total effect of the two actions represented by this equation is—

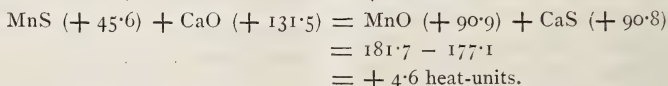
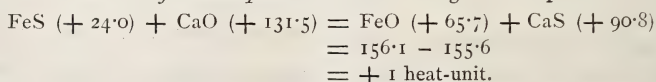


These equations show clearly why sulphur cannot be removed from the bath by an acid blow.

The formation of silicates from their elements is shown by the following equations (accepting for SiO_2 the value relating to the hydrate):—



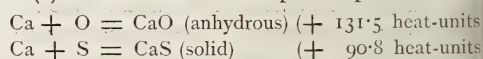
The Action of Lime upon Ferrous and Manganese Sulphides.



The figures above render it evident that manganese is a stronger base than iron and calcium stronger than manganese in silicates.

Lime can therefore decompose the acid iron and manganese silicates, or combine with them to form basic, *i.e.* ortho-silicates, *e.g.* FeCaSiO_4 . Hence the formation of manganese silicate in the acid "blow" is readily intelligible, notwithstanding the presence of an excess of iron.

(c) The action of lime upon sulphides:—

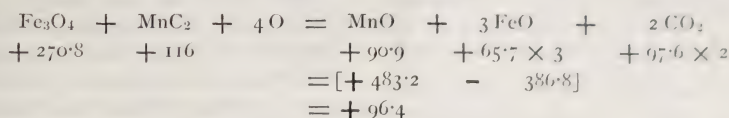


* Unfortunately, in the numbers used by Prof. Ponthière there are some errors which are to be found in the sources of information he consulted. For instance, we have for the heat evolved in the combustion of iron to form Fe_3O_4 , 230·6, 269·0, 276·4, and 270·8. This last number appears in the "Annuaire du Bureau des Longitudes" for 1898, and is presumably the most correct. In the volume of the same work for 1897, the combustion of the different forms of

carbon with oxygen has the minus sign before the figure thus making the reaction *endothermic*. This is evidently typographical error. There is one very important number, namely, 219·2 heat-units for the combustion of silicon to form SiO_2 . Berthelot, in his recently published work, "Lois et Données," vol. ii., 1897, gives this value as 179·6. Notwithstanding these inaccuracies, the general conclusions are not on the whole, affected in such a manner as to invalidate them.

The action is very feeble in the case of iron and not energetic with manganese, so that lime has little or no effect upon the removal of sulphur if it acts directly and in no other way upon the sulphides.

If we accept the number which Professor



This action cannot proceed farther in the direction of producing metallic iron because it then becomes an endothermic one.

Here we have a perfectly definite explanation of the action of manganese, accounting for three facts, namely:—

1. That iron in the bath does not burn so long as manganese is present, *e.g.*, the Swedish process.

2. That manganese added to the metal is found as slag with the composition of a manganese silicate.

3. That the addition of spiegel or ferro-manganese reduces burnt iron (Fe_3O_4) when introduced at the end of the blow.

Objection may be taken to any equation which introduces as an element in these calculations the oxidation of free phosphorus, or the action of lime on phosphoric anhydride, because it is almost certain that no such action takes place in the converter. Phosphoric anhydride, if produced in presence of so large a mass of basic material, whether iron, ferrous oxide, or lime, could only result first by the dissociation of ferrous phosphide and subsequently by the oxidation of the phosphorus. Now phosphorus and phosphoric anhydride are both volatile substances, and their spectra would become visible if they were free and uncombined, but though scrupulous care has been exercised in searching for the lines which are known to belong to their spectra they have not been found. It should here be mentioned that the spectrum of phosphoric anhydride is known, and has been described.* It follows therefore that the substance acted upon in the bath is ferrous phosphide, and this, when oxidised, either by Fe_3O_4 or by air, results in the production $\text{Fe}_3\text{P}_2\text{O}_8$, which in turn is removed into the slag by the action of lime, thus yielding $\text{Ca}_3\text{P}_2\text{O}_8$. But irrespective of this both manganese phosphide and ferrous phosphide are strongly exo-thermic substances.

Ponhière assumes to be the heat of formation of a manganese carbide of the formula MC_2 , namely + 116, then we may show how it operates in reducing magnetic oxide to ferrous oxide.

Thus:—

Now when grey pig-iron is being blown the temperature very soon rises to that point when the free carbon combines with the iron (see the curves upon which this is shown, pp. 714-16), and consequently what is oxidised is the compound ferrous carbide, Fe_2C , and not free carbon. We know, however, that the oxidation progresses, so that carbon monoxide CO is produced, and we are also aware that iron is oxidised, and that if dissolved in the bath the composition of the oxide is Fe_3O_4 .

When manganese silicide is oxidised it is extremely doubtful whether the element silicon is set free, or the compound silica produced, because the direct formation of a silicate slag, as MnSiO_3 , would be most likely to take place owing to the large amount of heat which would be evolved, and we know that such a slag is produced under the conditions of the "blow." Calculations based on the oxidation of Si to SiO_2 are therefore probably not accurate when manganese still remains in the metal bath.*

* There are some grounds for believing that silica is produced under certain conditions during the blow from a volatile silicon compound.

First, water vapour entering with the blast may yield silicon hydride and a metallic oxide as Fe_2O_3 and MnO or Mn_2O_3 .

Secondly, ferro-silicon when added to the bath in the Walrand-Legnèsel process gives an intensely brilliant flame during the "over blow."

Thirdly, silicon burns with difficulty in the oxyhydrogen blow-pipe flame, but it does burn and colours the flame blue.

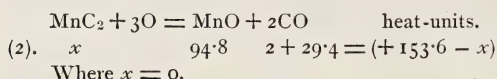
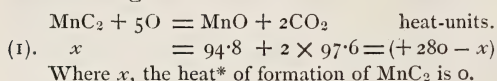
Fourthly, in Swedish Bessemer works a blue flame has been observed in very hot "blows" and for a short time only. Three lines in the spectrum of the flame have an agreement with three lines of silicon. (Lundström, "Proc. Roy. Soc.," vol. 59, p. 76).

Fifthly, it is a fact that manganese is volatilised from Bessemer slag, and is just possible that manganese silicide is volatilised, because the fume from the vessel is composed of a manganese silicate and ferrous silicate.

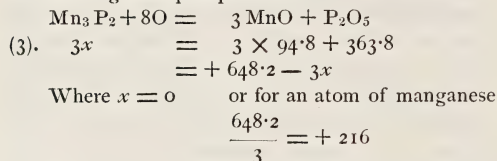
All the evidence I have obtained tends towards the opposite conclusion as regards silicon. These points are especially mentioned because in my earlier calculations on the heat evolved during the blow allowance was not made for the heat of formation of those substances present in the iron as compounds, by the subtraction of any ascertained or assumed value for each compound, but 50 per cent. of the heat was deducted from the whole.—W.N.H.

* Hartley, "Flame Spectra at High Temperatures" ("Phil. Trans.," vol. 185, p. 161, 1895).

The thermo-chemical equations for the combustion of the manganese carbide, MnC_2 , assumed to be present, first when the carbon is burnt to carbon dioxide, and secondly when it is converted merely into carbon monoxide, are the following:—



For manganese phosphide:—



In a similar manner the calculations for the following substances were made:—

	Heat-units.
Manganese sulphide .. MnS	164.2
Manganese silicide Mn_7Si_2 ..	157.2
Ferrous phosphide Fe_3P	129.9
Ferrous Carbide Fe_3C	
C burnt to CO_2	101.5
C burnt to CO	77.8
Ferrous sulphide FeS	138.2
Ferrous silicide FeSi	288.2

Fe_2Si discovered by M. Moisson contains 18 to 20 per cent. SiFe_2Si .

To render the numbers correct we should take into account the heat of formation of these compounds, and subtract this value. But accord-

* The number used here $\text{Mn} + \text{O} = \text{MnO}$ (anhydrous) + 90.9. Heat-units is more correct than the above, being taken from Berthelot's "Lois et Données," vol. ii., p. 265, 1897.

ing to Troost and Hautefeuille, though the heats of formation are positive for the first three, they are Zero or but negative values for the latter four. In any case the constituents of the pig-iron are often incomplete or ill-defined compounds.

But taking the experiments of Troost and Hautefeuille into account, it is the opinion of Professor Ponthière that by assuming the heat of formation of manganese carbide to be two-fifths, and that of manganese sulphide, silicide, phosphide, and also ferrous phosphide to be one-third of the values obtained if the elements are in the free state, he has a sufficiently near approximation for the purpose in view.

The heats of combination are therefore assumed to be as follows:—

	Heat-unit
Manganese carbide MnC_2	116
Manganese phosphide	72.3
Manganese sulphide	54.8
Manganese silicide	52.5
Ferrous phosphide	43.3

These figures then, though not absolutely correct, if deducted from the heat of combination of the same compounds, yield the heats of combustion of the constituent substances in the iron. Professor Ponthière has calculated the following Table, though it is not put forward as strictly accurate owing to the lack of certain data.

* The latest data are the following:—

	Heat-units.	Heat Units
$\text{Mn}_3 + \text{C} = \text{Mn}_3\text{C}$ [+ 9.9]		
$\text{Mn}_3\text{C} + 3\text{O}_2 = \text{Mn}_3\text{O}_4 + \text{CO}_2$ [+ 412.4]		Le Châtelier, C. R., c. xxii., 81; 1896, Berthelot, "Lois et Données," vol. ii., p. 270. 1897.
$\text{MnS} = \text{MnS precipitated}$ [+ 45.6] (p. 269).		

HEAT OF COMBUSTION OF THE CONSTITUENTS OF CRUDE IRON.

	I. Heat of formation per gramme atom of the metal, assumed to be 1-5th of II. when not formed.	II. Heat of combustion of the free elements per gramme atom of the crude metal.	III. Heat of combustion resulting per gramme atom of the crude metal.
Manganese carbide, MnC_2			
If only the carbon of the compound is burnt—			
C burnt to CO_2	116.0	290.2	174.2
C burnt to CO	116.0	153.8	37.8
Manganese phosphide, Mn_3P_2	72.3	216.8	144.5
Manganese sulphide, MnS	54.6	164.2	109.4
Manganese silicide, Mn_7Si_2	52.5	157.6	105.1
Ferrous silicide, FeSi	negligible	288.2	288.2
Ferrous sulphide, FeS	negligible	138.2	138.2
Ferrous phosphide, Fe_3P	43.3	129.9	86.6
Ferrous carbide, Fe_3C			
If only the carbon of the compound is burnt—			
C burnt to CO_2	negligible	101.5	101.5
C burnt to CO	negligible	77.7	77.7

The differences between the figures in the first and second columns give the values in the third column. It is pointed out that those belonging to the ferrous compounds—carbide, sulphide, and silicide—of which the heat of formation has not been determined, but which is more or less negative, though still negligible, are a little too low, but without influence on the results. There is one point the consideration of which conduces to the simplification of the calculations, and enables us to take a rapid survey of the heating effect, the combustion of the two metals iron and manganese, and it is this fact that one gramme atom of either element is very nearly the same quantity, their respective atomic masses being 56 and 55. We may thus observe by simply glancing at the figures in column 3, the enormous heat of combustion of the ferrous and manganese silicides, and the ferrous and manganese carbide, when approximately equal weights of the two metals are involved. These substances play a most important part in the oxidation of impurities in the *acid process*. We can thus understand the enormous heating effect of the “blow” both in the slag-forming period and the “boil.”

Miscellaneous.

ELEMENTARY EDUCATION IN GERMANY.

The Germans attach much importance to compulsory education from the earliest youth, but as regards children of the working-classes, in view of the small number of teachers, in proportion to those who have to be taught, the chief advantage gained is giving the latter regular habits and keeping them out of mischief, especially, as under military principles, a control is exercised by the school masters and mistresses not only in but out of school. Consul Mulvany, of Düsseldorf, says, that it is only natural that such a forced system should not be very highly valued by the recipients and that only a few of the more intelligent children derive much material benefit, but it affords an opportunity to the authorities of testing the quality of brain with a view of development to higher posts in the interests of the pupils and of the State. The education of children is absolutely compulsory from the age of 6 to 14; only in exceptional cases where the child is considered to be sufficiently advanced and is required at home is there a departure from this rule. All elementary schools are free of fees; in small villages there are eight different divisions, though the children may be possibly taught in one room by one and the same master, whereas in towns it is found sometimes necessary to subdivide the

division, thereby forming 16 different classes. There are no examinations. These schools are supported partly by the State, partly by the community, in most cases the State paying about half the cost; as to proportion very much depends upon the tax-paying powers of the community; as a general rule there is no special school tax. In religious education the children are separated according to confession; all must attend Bible history classes; the appointment of school masters is determined in accordance with the preponderance of the Roman Catholic or Protestant religion. There are special seminaries where teachers of both sexes are qualified for higher grades of education; the community appoints the teachers subject to the sanction of the State. Children between 6 and 14 years of age can only receive education from duly qualified teachers; no one is allowed to teach at either private or public schools without having passed a specified examination. If parents, no matter what their social rank may be, neglect to have their children taught during the age from 6 to 14 by a qualified teacher they are compelled to send them to the public elementary school. All higher schools levy fees. Private schools can only be established under sanction of the State. All schools are subject to the supervision of Government inspectors, whose duty it also is to see that children of men of high rank, even when educated in their parents' house by private tutors or governesses, receive that education from thoroughly qualified persons. Consul Mulvany quotes a case in point, where the inspector insisted upon examining the tutor and the pupil, a boy of some six or seven years of age, as to proficiency. The elementary or preliminary period of education being completed, that is, in the working-classes, the boys and girls apprenticed to qualified masters in any trade or business, the same have to attend the evening classes of technical *Fortbildungsschulen*, which now are compulsory; all branches of trade and industry are represented, and even in the higher classes this further education is brought within such easy reach of all that an important groundwork is formed to which in a great measure may be attributed the great strides made in industrial and commercial development. The higher class schools for general education are *Real Schulen*, where chiefly modern languages and mathematics are taught to lads who are intended for technical and commercial life; and the *Gymnasium* where classics and that class of education is given to prepare for higher professions, such as the Church, the Army, Navy, and the Bar; these are State institutions, being public day schools. Very few boarding schools exist in the country, and they belong to private individuals. The fees of the public schools are extremely moderate, so that they are open to all comers who can pass the necessary school examination. On the school bench no distinction is made between the highest members of the aristocracy and the sons of even the lower middle-classes, so that the man of title later in life buys his shoes and stockings from a school companion who may have passed a

better examination than he, and this in a country where the distinction of class is much more marked than in England. There is still a higher class of technical schools or colleges where students take diplomas for professions, for instance, in agriculture, forestry, viticulture, engineering in all its branches, and all of course under State supervision.

THE POPULATION OF RUSSIA.

The Central Statistical Committee of St. Petersburg has recently prepared a report dealing with the question of the population of Russia. According to this report, the population in fifty provinces of European Russia numbers 94,215,000, of whom 46,447,000 are males and 47,767,000 females. In ten of the Previsliansky provinces the population is estimated at 9,455,000, of whom 4,764,000 are males and 4,691,000 females. The number of the population in the Caucasus is 9,248,000, of whom 4,891,000 are males and 4,357,000 females. Siberia has a population of 5,727,000, of whom 2,954,000 are males and 2,772,000 females. The population of Central Asia was determined at 7,721,000, of whom 4,138,000 are males and 3,583,000 females. The total is 126,366,000, and counting the Russians in Finland, and also those on board the various battleships in foreign ports, in Bokhara, and Khiva, the general total of the population of the Russian Empire is estimated at 126,411,000, of whom 63,253,000 are males and 63,158,000 females. According to the census of 1897, in the towns of fifty provinces of European Russia there were 11,830,000; in the towns of ten of the Previsliansky provinces, 2,058,000; in towns of the Caucasus, 996,000; of Siberia, 462,000; of Central Asia, 932,000; and of the Bokhara, 8,000. In this manner, the population of the towns of Russia is equal to 16,289,000; that is, the population of the towns represents about 13 per cent. of the total population of the Empire. If, however, the villages and small settlements are included, the actual town population will not be less than 20,000,000.

THE COREAN POSTAL SYSTEM.

Corea has a domestic postal system, and the service gives satisfaction. While Corea has formally entered the Postal Union, a foreign service has not yet been arranged, and the Japanese postal department still continues to serve Corea. The stamps are of four denominations—5 poon, equal to one halfpenny, green; 10 poon, equal one penny, blue; 25 poon, equal 2½d., brown; 50 poon, equal 5d., purple. At present, there are no printed covers, postal cards, or other stamped postal paper. The stamps, which were printed in the United States, are all alike, except in colour and denomination. The characters at the top are ancient Chinese, those at the bottom are Corean, and have the same meaning as the row at the top. The characters at the right are Corean, and

give the denomination which is translated in English just below the centre. Those on the left are in Chinese, and mean the same as those on the right. The plum blossom ornaments each corner. This is the royal flower of the present Ye dynasty which has been in existence for 505 years. The national emblem in the centre is the ancient Chinese representation of the male and female elements of nature. The four characters at the corners of the centre piece are taken according to the American Consul at Seoul, from whom the above description is quoted, from "the original alphabet of all languages and represent the four spirits that stand at the corners of the earth, and support it on their shoulders." A set of three stamps costs ninepence. They can be cancelled at the post office if desired.

Correspondence.

PARLIAMENTARY RETURN OF SECONDARY AND OTHER SCHOOLS.

As Mr. Macan rightly opines, technical schools, which is, however, the exact expression of the Report, are meant to be taken in the sense of technological. The definite setting of these institutions outside the pale that is gradually being formed round secondary education seems to me to be a happy augury of further discrimination later on. It was obvious I could not have been thinking of that distorted yet temporarily legalised meaning of technical; which embrace within its definition such an essentially secondary subject as English grammar. The last part of the paragraph was clearly meant to refer to secondary education in general; there was, therefore, no direct allusion to local authority schools, as such, any more than to the endowed schools, or any other of the scholastic divisions under which the report has grouped secondary education.

CLOUDESLEY BRERETON.

July 10, 1898.

General Notes.

BERLIN PAVEMENTS.—It appears from some statistics furnished by the United States Consul at Berlin respecting the carriage pavements of that city, that wood pavement does not find much favour there. The area of pavements is 6,500,405 square yards, and of this area a little less than 74 per cent. has stone pavements, about 25 per cent. asphalt, and a fraction over 1 per cent. wood. The Consul states that the proportion of asphalt is steadily increasing. The soil consists of coarse gritty sand, forming apparently an excellent foundation for the heavy 8 in. layer of gravel and cement, over which the 2 in. covering of asphalt is spread.

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FRIDAY, JULY 22, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Proceedings of the Society.

CANTOR LECTURES.

THE THERMO-CHEMISTRY OF THE BESSEMER PROCESS.

BY PROF. NOEL HARTLEY, F.R.S.

Lecture III.—Delivered March 28, 1898.

THERMO-CHEMICAL EFFECTS OF THE "ACID" PROCESS.

If we consider the blowing of iron containing little manganese, and for this purpose refer to the diagram of the "blow" as it occurs in the examples given by the analytical results of Snelus, we have first a complete oxidation of the small quantity of manganese during the first four minutes. It is quite possible that it is alternately oxidised and reduced, oxidised by the blast and reduced by the metallic carbides or free carbon in the bath, but neglecting this for the moment we have extremely rapid oxidation of the silicon, or manganese and iron silicides, the conversion of graphite into ferrous carbide, and the oxidation of the carbon of the carbide to CO_2 in the same period. It would appear then that while we are burning ferrous carbide to CO_2 at the rate of + 101.5 heat-units per gramme-atom of metal we are forming manganese carbide or the so-called combined carbon at the rate of + 116.0 heat-units per gramme-atom of manganese, and the heat thus evolved must be added to the heat evolved by the combustion of ferrous silicide. It is a well known fact that the temperature rises at times with great rapidity and as a rule it is more easy to obtain too high rather than too low a temperature even in the early stages of the "boil" when working the acid process. But why is the carbon at the slag-forming period oxidised to CO_2 , and subsequently no farther than the product CO ? This appears to be due to the cumulative rise of temperature approaching or even rising to the temperature

of dissociation of CO_2 in presence of the other combustible elements such as iron.

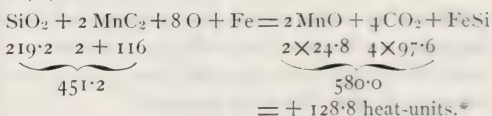
In considering the effect of the "blow" on a highly manganiferous pig-iron we have a rapid oxidation of manganese down to the end of the first period, and doubtless this element is partly if not chiefly contained in the compound manganese silicide while there is doubtless a production of manganese carbide.

In fact here several chemical actions occur simultaneously or overlap in such a manner as to evolve the greatest amount of heat, and to explain these it is desirable to consider the thermo-chemical equations. Equation (1) is first realised, and after the first six minutes chiefly equation (2).

When the metal contains much manganese because of an excess of manganese carbide in it (as for instance 3.46 per cent., in the metal referred to by Brunner and Kupelwieser) this element is oxidised before the silicon is attacked, but supposing the compound manganese silicide is the substance oxidised as we know to be case, the course of oxidation will give us MnO and SiO_2 , but the apparent paradox as seen by the light of the diagram is accounted for by a reduction of the silica in presence of iron to ferrous silicide by manganese carbide thus:—

Thermo-Chemical Reactions of the Bessemer "Blow."

(1.)



Professor Ponthi  re writes this equation with ten atoms of oxygen, as if the oxidation of the silicon had not already taken place, his number therefore differs from mine slightly.†

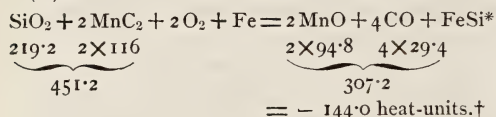
But ferrous carbide in acting on silica gives a negative sign as may be verified by the thermo-chemical equation, and experience shows that silica is not reduced by ferrous carbide, while, on the other hand, manganese carbide is a most effective reducing agent for silica. There

* Berthelot, vol. ii., p. 151.

† Professor Ponthi  re observes that this equation explains the action on the manganese alone before the attack of the silicon during the first minutes of the "blow" with highly manganiferous irons, and also the analyses of Kupelwieser and Brunner quoted by Hartley as relating to a Bessemer charge contains 3.46 per cent. Mn and 1.96 per cent. Si. As these analyses deal with Bessemer metal containing only traces of phosphorus and sulphur, they can be explained only by the equation where the manganese carbide reduces the silicon, and the carbon is oxidised to carbon dioxide. If carbon monoxide be produced it may be remarked that the result is negative.

is further a most interesting fact shown by the thermo-chemical equation (2), namely, that if the carbon be oxidised only to carbon monoxide, instead of to dioxide, the effect is negative, and therefore probably does not and cannot take place.

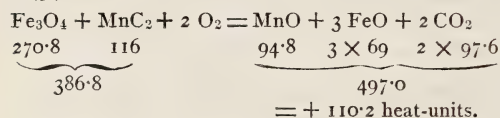
(2.)



During the "boil," the temperature rises, and is easily made too hot, because manganese, carbon, and silicon are all being oxidised together during the fining stage; here the iron is oxidised to Fe_3O_4 , and the melting point of the metal is raised, the temperature falls, and the contents of the vessel became pasty. At this stage the silicon has been withdrawn, and is in the condition of slag, chiefly manganese silicate, MnSiO_3 .

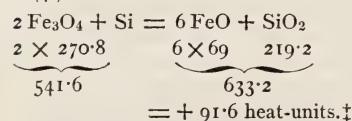
The addition of spiegeleisen, which contains a large proportion of manganese carbide, reduces the magnetic oxide to ferrous oxide according to the following equation (3):—

(3.)



Silicon is oxidised at the expense of the magnetic oxide, and thus reduces it to ferrous oxide as in equation (4); but here again the presence of free silicon is assumed.

(4.)



In the latter stage of the process we have a formation of slag from the remnants of the impurities which the magnetic oxide has oxidised. This action takes place upon thorough mixing, either in the converter or in the ladle.

* Where Professor Ponthière's equations deal with compounds such as FeSi (ferrous silicide), it should be understood that these, according to his view, are constituents of crude iron.

† (Amorph.) Heat-units.

$\text{Si} + \text{O}_2 = \text{SiO}_2 + 179\cdot6$

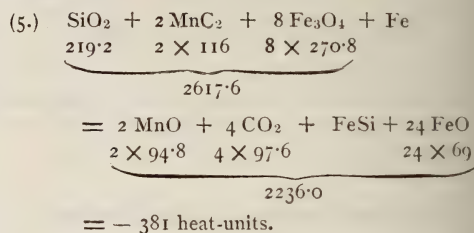
(Crystal) Heat-units.

$\text{Si} + \text{O}_2 = \text{SiO}_2 + 184\cdot5$.

See p. 621, Ann., 1898. Tr. and H.B. This is not an error, apparently. See ditto, p. 14.

‡ Prof. Ponthière uses 230·6 for Fe_3O_4 and states that this number is taken from the "Annuaire du Bureau de Longitudes" for 1897. In the volume for 1898 it is 270·8.

If the mixture was made by a short blowing, probably some of the silicon would be reduced, and ferrous silicide would be produced thus, equation (5):—



But this action would not occur if the oxygen were supplied solely by the magnetic oxide since there is an absorption of heat.

A comparison of these equations shows that there can be little doubt that manganese silicide is oxidised directly to manganese silicate, and that this may be converted into ferrous silicide by ferrous carbide when there is an excess of carbide of manganese or insufficiency of silicon. It must be remembered that the temperature is very high, a condition favouring the formation of ferrous silicide. This appears to be one reason why it is preferable not to turn up the converter for a short after-blow after the addition of spiegeleisen, but to allow the reaction to take place in the turned down converter or in the ladle. If the manganese is sufficiently large in amount, the first portion disappears at the beginning, and then manganese silicide is generated from the ferrous silicide, or ready formed manganese oxide may displace the iron from ferrous silicide or silicate, and form the corresponding manganese compounds, the manganese silicide oxidising to manganese silicate.

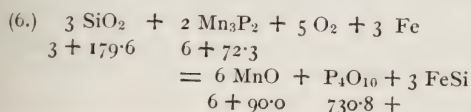
It is a fact well known that with little manganese in the bath the process must be stopped for a final addition either of spiegeleisen when carbon is required in the final product, or of ferro-manganese as already mentioned, when soft iron is to be obtained. But in the Swedish works it was the custom to arrest the blow before the final removal of manganese and add nothing to the bath, and this became possible only because the proportion of manganese in the crude metal was very high. For an explanation of this I have already given you an equation.

THE THERMO-CHEMICAL EFFECT OF THE "BASIC" BESSEMER PROCESS.

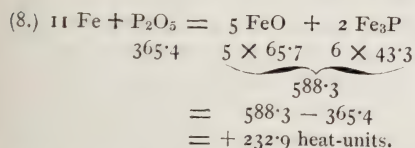
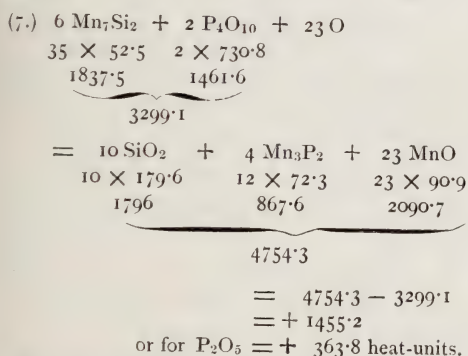
In the "basic" process it must be remembered that lime is added in large proportion, and that there is a considerable "over-blow."

In the first instance two tons of lime are added to twelve tons of blast-furnace metal, at the commencement. Ferrous silicide at the head of the list (p. 730, heat of combustion of the constituents of crude iron) is first attacked, and it is said to yield silica and magnetic oxide. The substance formed, however, is ferrous silicate FeSiO_3 . But manganese carbide and phosphide, when their percentages are sufficiently high in the presence of iron or under the oxidising action of air under pressure traversing the bath may reduce both magnetic oxide and silica, as also a ferrous silicate. The case of the carbide has already been dealt with in a previous equation, No. 1, p. 733, where 128.8 heat-units were shown to be evolved.

In the case of manganese phosphide the equation (6) is stated as follows:—

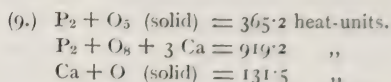


The phosphoric anhydride produced by this reaction which is not in the free state may be reduced by the manganese silicide and by metallic iron if not at once removed by the lime, as the equations (7) and (8) here following will show:—

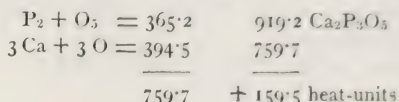


Now ferrous phosphide evolves only about 30 heat-units in its formation from the compounds FeO and P_2O_5 , so that these equations would be realised if no lime were present. But as equation (7) above shows there is manganese phosphide produced which in turn is decomposed yielding manganese oxide which combines with the silica; and ferrous phosphide by the reduction of P_2O_5 in contact with

Fe is produced. The action of lime in the "basic" process converts any ferrous phosphate in the slag to calcium phosphate, the heat evolution being high, as can be seen from the following figures:—



The heat of formation of 3CaO is therefore + 394.5 units. Accordingly we have—



159.5 heat-units are evolved by the union of P_2O_5 with 3 CaO , while FeO and P_2O_5 evolved only about 30 units.

In a "basic blow" the metal should contain but little silicon, but the phosphorus may however be in considerable proportion. Accordingly the action of the "blow" does not cause a high temperature during the boil, there being carbon, manganese, sulphur, and phosphorus to burn, but no silicon; there is also the lime which reduces the temperature. This has been deduced from experiments and observations made on the spectrum of the flame during the blow when the acid and basic processes have been compared.

Now the lime plays two parts, one is that of a base more powerful than iron and manganese which therefore combines with the sulphur. We have it then acting as a powerful base preventing the waste of iron and also fixing the phosphorus in the form of calcium phosphate.

VARIATIONS OF TEMPERATURE DURING THE BLOW.

In the combination of oxygen of the air with the impurities in the metal, we have a combustion within the converter which generates a high temperature, and this may be calculated from the weight of air necessary to the process. We may, on this basis, calculate the weight of the products of combustion, and the heat carried away as the gases leave the vessel.

The only gaseous products are carbon monoxide, carbon dioxide, and nitrogen.

From the atomic weights, we may calculate that a gramme of manganese silicide required for oxidation 324 grammes of oxygen, which is accompanied by 1079 grammes of nitrogen. Assuming, from figures derived from previous

work, that the temperature of the flame at the mouth of the converter is 1700°C. ,* the heat carried off by 1079 grammes of nitrogen, is $1079 \times 0.2438 \times 1700 = 447.2$ kilo heat-units.

The products of the combustion are liquid slag, which remains inside the converter, small portions only being ejected. The heat of combustion resulting from one-seventh $\text{Mn}_7\text{Si}_2 = 441 \div 7 = 63$ grammes of manganese silicide, amounts to 105.1 heat-units; one kilogramme of silicide evolves 1,666 heat-units, and leaves in the converter $1666 - 447.2 = 1218.8$ heat-units.

The calorific efficiency thus becomes—

$$\frac{1218.8}{1666} = 0.73.$$

When ferrous carbide is burnt with the production of carbon dioxide there is found for one kilogramme—

Weight of oxygen required	268 grains.
Weight of nitrogen corresponding ..	892 grains.
Heat carried off by the nitrogen....	$0.892 \times 0.2438 \times 1700 = 369.67$
Heat carried off by the carbon dioxide.....	$0.245 \times 0.245 \times 1700 = 102.04$
Total	471.71 Heat-units.

Heat evolved by the burning of 1 kilogramme of $\text{Fe}_3\text{C} = 1691$. Effective heat evolved—

$$1691.00 - 471.71 = 1219.29 \text{ heat-units.}$$

Let us take into account now the heat evolved by the combustion of the solid constituents in the metal, such as carbon or carbides, silicon or silicides, and manganese, which burn alone, then ferrous carbide and silicide. The heat of combustion is given in the thermo-chemical tables. Manganese phosphide, when the manganese and phosphorus are both burnt, is calculated from the total amount already given in the tables minus the heat of combustion of the phosphorus, and, referring to the standard quantity of one kilogramme, from which the heat carried off by the gases is deducted.

No attempt is made to ascertain the heat lost by the slag thrown out of the converter, which must be not only exceedingly difficult to determine, but also a very variable quantity;

* Professor Ponthière assumes the temperature to be no higher than that of cast-iron in the molten state, viz., 1200°C. , but from certain consideration I believe it to be much higher, and have taken the figure to be 1700°C. , and made the calculation accordingly.

nor for the loss by radiation from the converter. This is liable to be over-estimated, since we start with the converter hot. In any case it is a constant. The result is given in the Table (p. 737).

No account is taken of the conversion of the graphite in grey pig-iron into ferrous carbide, which results in an absorption of heat, though this in the acid process really appears to be the first effect of the blow, as seen by the diagram drawn from the analytical data obtained by Snelus. The fact must be noted, however, that in this case the pig-iron was melted in a cupola, whereas in Professor Ponthière's calculations such a consideration would not enter, the metal being drawn direct from the blast furnace, and the carbon being then in combination with iron (as Fe_3C).

The order of attack of the constituents in the bath by the aid of the preceding Table enables us to form some idea of the cause of the variations in temperature during the course of the "blow."

First, there is combustion of the silicon	Heat-units.
yielding	6,230
Silicide of iron yielding	2,980
Manganese carbide.....	1,196
Second, the loss due to combustion of manganese phosphide.....	127
is made up of, or by the burning of the manganese sulphide	1,079
and manganese silicide	1,351
which has not yet been already utilised in the reduction of phosphoric acid.	
The combustion of part of the carbon only	3,498
or ferrous carbide.....	1,364
increases the elevation of temperature.	

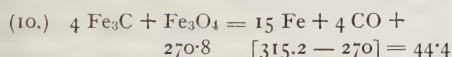
As the temperature rises, the burning of carbon to carbon dioxide becomes no longer possible, and it is then as carbon monoxide that the larger proportion of carbon in the ferrous carbide, either as carbon burning by itself or with the iron. In the former case 188 heat-units are evolved, or with the iron 1,364.

The bath then cools in proportion as carbon monoxide is evolved. The metal becomes less fluid, its melting point is higher, the blast exercises its full effect upon the metal, giving abundant oxide Fe_3O_4 , which makes the metal become pasty. The remainder of the ferrous carbide which forms the greater proportion of the whole amount, together with the manganese carbide which has so far escaped oxidation

EFFECTIVE HEAT IN THE CONVERTER RESULTING FROM THE COMBUSTION OF 1 KILOGRAMME OF EACH CONSTITUENT OF THE IRON.

Substance.	Per gramme atom of free element metal or metalloid.	Per kilo. of consti- tuent, or of free metalloid.	Heat removed by the gases per kilogramme.	Heat left in the bath per kilogramme.	Calorific efficiency per cent.
Silicon	219.2	7,326	1,096	6,230	84
Ferrous silicide	288.2	3,430	450	2,980	86
Manganese silicide	105.1	1,666	315	1,351	81
Manganese phosphide	144.5	1,911	539	1,372	71
Manganese only burnt in the phosphide	22.7	412	285	127	30
Manganese sulphide	109.4	1,257	178	1,079	85
Manganese carbide, C burnt to CO ₂	174.2	2,205	1,009	1,196	54
Carbon to CO ₂	97.6	8,080	4,592	3,498	45
Ferrous carbide, C burnt to CO ₂	101.5	1,691	327	1,364	80
Ferrous carbide, C burnt to CO	77.7	1,295	217	1,078	83
Carbon burnt to CO	29.4	2,450	2,262	188	8
Manganese carbide, carbon burnt to CO	37.8	478	638	-160	-33
Ferrous phosphide	86.6	1,305	384	921	70
Metallic iron	69.0	1,232	346	886	71

reduces part of the magnetic oxide formed by the blast, and carbon monoxide is evolved according to equations (3) and (10)—



There being a deficiency of reducing substances present, the magnetic oxide diffuses itself through the metal.

Now Professor Ponthière draws an important conclusion that from the low calorific power of manganese carbide, it possesses great stability, which explains why it is not, as he states, attacked except indirectly in the first instance, and why highly magniferous iron can be treated without final additions. We now can understand that the Swedish direct process differs from the ordinary acid and basic processes by a considerable proportion of manganese carbide being unacted on all through the blow, and which so renders unnecessary any final addition of metal containing this substance.

In the basic process, the phosphorus, which at the end of the blow is entirely in the form of ferrous phosphide, adds two sources of heat during the "over-blow" by the combustion of Fe_3P to $\text{Fe}_3\text{P}_2\text{O}_8$, and the action of this upon lime gives $\text{Ca}_3\text{P}_2\text{O}_8 = (+ 921 \text{ heat-units})$. The total effect of the oxidation of ferrous phosphide into ferrous phosphate, and the action of lime upon this, is to give a strikingly exothermic reaction. This is the cause of the heating effect.

Finally, when manganese alloy (spiegeleisen

or ferromanganese) is added, the Fe_3O_4 is reduced to FeO , when it combines with any free SiO_2 , at the same time MnO is produced, and this oxidation causes the last evolution of heat (provided the matter added is in the fused state). In this instance, therefore, it should be spiegeleisen. This recarburiser lowers the melting-point of the metal in the bath, and so increases its fluidity. At the same time it increases its temperature by the oxidation of the carbon or the manganese. This explains Le Chatelier's measurement of the temperature of basic steel in the ladle from a Robert converter (this was probably from basic treatment, but this is not stated) giving a higher temperature than that of the metal in the converter itself. (See Lecture I., p. 717.)

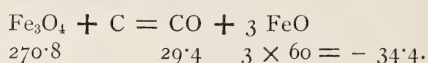
THE ACID AND THE BASIC PROCESSES
COMPARED.

In the acid process, the high per-centage of silicon and the absence of any lime causes the first stage to be very hot; in fact, it is difficult with large charges and rapid blowing to keep the temperature down. As Professor Ponthière states, the metal is much hotter than in the basic converter. The temperature is maintained until the last half minute of the blow.

In the basic process, whatever the heat evolved by the blow, much is taken up by the lime, but the temperature towards the end of the blow increases, owing to the oxidation of the ferrous phosphide and its union with the lime, which evolves a large amount of heat,

but this may be absorbed by an abundance of slag, and the temperature may be so reduced as to necessitate the addition of phosphoric slag when it rises again. In this case the phosphate must undergo, 1st, reduction in the bath, and, 2ndly, oxidation by the blast. In point of fact, the more phosphorus the hotter the bath in the "basic," whereas in the "acid" process the more silicon the hotter the bath.

Recarburisation in the basic process may be made without large additions of manganese by the use of coke or briquettes, which dissolves in the metal and hardens it; which with the high temperature prevailing can reduce the Fe_3O_4 as far as FeO , thus—



Dealing with a comparison of the Bessemer with the refining process, it is remarked by Professor Ponthière that there is in both an absence of basic slag and a strongly oxidising atmosphere, with the result that silicon is almost the only substance eliminated, for manganese was very seldom present in the metal refined. The slag then consisted of ferrous silicate.

Rigorous exactitude in the calculations dealing with such complex materials as pig-iron and slags formed therefrom consisting largely of silicates of manganese and iron cannot at the present time be attained or even expected, because in the pig-iron our knowledge of the compounds in which the elements exist is not exact, and the thermo-chemistry of the formation of silicates is something altogether unknown at present. Even the specific heat of the slag is not known, and many other data are wanting. When we know our shortcomings there is some probability of improvement or advancement of our knowledge.

INVESTIGATIONS OF THE SPECTRA OF THE BESSEMER FLAME.

The flame issuing from the mouth of a Bessemer converter was first investigated by Sir Henry Roscoe* in 1863; by Lielegg,† and by Marshall Watts in 1867;‡ by Turner,§ J. M. Silliman, Rowan,|| Von Lichtenfels,¶

Spear Parker,* Kupelwieser,† Brunner,‡ and Wedding in 1868;§ also by A. Greiner in 1874.||

When I first attacked this subject, the precise nature of the spectrum, the cause of its production, its sudden disappearance when decarburisation of the metal takes place, and the connection between the decarburisation of the metal and the extinction of the spectrum, had not been satisfactorily explained. According to Roscoe, Lielegg, Kupelwieser, and Spear Parker, the spectrum was characterised by bands of carbon or of carbon monoxide, which disappeared when all carbon is burnt out of the metal.

On the other hand, according to the investigations of Simmler,¶ Brunner, Von Lichtenfels, and Wedding, the spectrum was not due to carbon (Roscoe) or to carbon monoxide (Lielegg and Kupelwieser), but to manganese and other elements in the pig-iron.

The very careful work of Dr. Marshall Watts, led to the belief that it was not the spectrum of carbon, nor of manganese, but that of manganic oxide. Lielegg proved that carbon monoxide yields a continuous spectrum, and that this gas causes the continuous bright spectrum of the Bessemer flame; but he also attributed certain lines or bands to the high temperature of carbon monoxide. Marshall Watts first established the fact that six lines in the spectrum of iron were present in the Bessemer spectrum. In 1874 Greiner** observed in the flame from highly manganiferous pig-iron the spectrum of manganese as figured by Wedding.

In 1882 I devised the instrument you see upon the table; it is a modification of that described in the "Scientific Proceedings of the Royal Dublin Society," vol. iii., p. 23, new series, 1881 (see also "Thorpe's Dictionary of Applied Chemistry," Spectroscope). This was intended to meet the requirements of a series of observations to be made at steel works, particularly for studying the spectra of flames and the heated gases of open-hearth furnaces. It was desirable that it should give a fair amount of dispersion at the less refrangible end or the spectrum, and be rigid and portable. A train of four quartz prisms, in con-

* "Manchester Literary and Philosophical Society's Proceedings," vol. iii., p. 57, and "Philosophical Magazine," vol. xxxiv., p. 437.

† "Sitzungsberichte Kaiserl. Akademie der Wissenschaften, Wien," vol. li., part ii.

‡ "Philosophical Magazine," vol. xxxiv., p. 437.

§ "Dingler's Polytechnisches Journal," vol. clxxviii., p. 465.

|| "Philosophical Magazine," vol. xli., p. 1.

¶ "Dingler's Polytechnisches Journal," vol. cxc., p. 213.

* "Chemical News," vol. xxiii., p. 25.

† "Oesterreichische Zeitschrift für Berg- und Hüttenwesen," No. 8, p. 59, 1868.

‡ "Loc. cit.," No. 29, p. 227, 1868.

§ "Zeitschrift für das Berg-, Hütten- und Salinenwesen im preussischen Staate," vol. xxvii., p. 117, 1869.

|| "Revue Universelle des Mines," vol. xxxv., p. 623.

¶ "Zeitschrift für Analytische Chemie," 1862.

** "Revue Universelle des Mines," vol. xxxv., p. 623, 1874.

struction similar to those first used by Cornu and by L. Soret, was at first arranged on a table and stand made entirely of wood, to which a camera was fitted, with a rack and pinion movement to the frame holding the dark slide, so that as many as thirty spectra could be photographed on one plate. Various trials with this mounting showed that, owing to the stand being too light, the instrument was unsteady. Instead of four quartz prisms, a single prism of calcite may be employed if the surfaces are well protected from dust; but though this simplifies the instrument, the stand for it must still be massive. In 1887 the quartz train was mounted on a heavy iron tripod stand. The prism table is fixed to the pillar of the stand by a winged screw-joint and counterpoised, so that it could be placed in almost any required position. The camera is of metal, with an eye-piece behind the frame for the dark slide, so as to make it available for observations with the eye, for which it is peculiarly well adapted, owing to the observer having the flame behind him, and therefore he is not embarrassed by the glare. It has, however, not been used for this purpose, because photography is preferable to eye observations. In the circular box at the end of the camera, the dark slide can be fixed at any angle, as it is rotated by means of a toothed wheel. The collimator, and telescope or camera, are marked with a scale of millimetres on the draw-tubes, so that both the slit and photographic plate may be drawn out so as to be equidistant from the lenses for the purpose of focussing correctly. The camera can be clamped, and its exact position determined by means of a divided arc on the prism table. The prisms move automatically with the camera, in order to secure the minimum angle of deviation for the mean rays photographed. A brass rod in front of the slit, and fixed to the prism table, carries a condensing lens of three inches focus. Sometimes two cylindrical lenses were used, this being the form of condenser used by V. Schumann with excellent results as regards definition, but in the case of Bessemer spectra it was more convenient to use one spherical lens of quartz. With the usual form of condensing lens an image of the flame was projected upon the slit, sometimes the flame was in the same vertical line with the slit, and sometimes placed diagonally. This depended very much upon the position of the converter and the consequent size of the image. The slit plate was covered with a thin plate of quartz to exclude dust and dirt. This detail, though

only a small matter, is of considerable importance, as will be understood when I state that the instrument once became covered with powdered lime to a thickness of half-an-inch, when a photograph was being taken, but, by wiping the quartz plate, no interruption occurred in taking a series of photographs. A metal plate, with a V-shaped piece cut out of one end, slides over the window of quartz, and serves to shorten or lengthen the slit, and secure a greater or smaller number of spectra on one photographic plate. In some cases, a photograph was taken every half-minute, from the commencement to the termination of the "blow." This could be accomplished only by the use of such a contrivance, as the plates measured no more than 3 by $2\frac{1}{2}$ inches.

To focus the instrument, various photographs of sun-spectra were taken, and the positions of the different adjustable parts were recorded. In order to render the instrument portable, a case was constructed for carrying the prism table, prisms, collimator, and camera, without disarranging the adjustment of the instrument. A winged screw, when loosened, enabled the whole to be detached from the vertical pillar of the tripod, the counterpoise, of course, having been detached previously. The prism table was then fastened in its case. A second case carried the tripod, counterpoise, chemicals, and developing dishes. This case when empty had a square frame of wood which fitted into the top when the lid was open. The frame was covered with waterproof cloth lined with yellow calico. In the cloth were arm-holes and sleeves fitted with elastic, which came half way up to the elbows. The developing dishes and measured quantities of solution were placed ready in the box before operating, and the dark slide could be opened, the plate removed and placed in the developer, while during development a new plate could be put into the slide. Development was always allowed to proceed for a given period of two minutes, which previous experiment had proved to be sufficient. During the progress of development the dish was covered with an ebonite tray to exclude any possibility of light reaching the photographic plate. By such means the plates are developed and fixed without the use of a dark room, but it is, of course, essential that the hands are not withdrawn from the box before the development is concluded.

Having given you a slight outline of the history of the subject and a description of the instrument used, I may mention that for some years prior to visiting the Bessemer works the

spectra of gases in combustion, of metals, and of metallic oxides, were being carefully studied.

Gases.—Hydro-carbons show the band spectrum which is well-known, also the spectrum of water-vapour lines. Carbon monoxide was proved to give nothing beyond a continuous spectrum when perfectly uncontaminated by any other material, such as dust in the air.

Metals and Non-metallic Elements—

The following characteristic flame spectra are emitted at high temperatures :—

- I. Line spectra.—Lithium, thallium, nickel, cobalt.
- II. Banded spectra.—Antimony, bismuth, gold, tin, sulphur, selenium.
- III. Banded spectra with lines.—Copper, iron, manganese, tellurium, lead, and silver.
- IV. More or less continuous spectra with lines.—Sodium, potassium, magnesium, chromium, cadmium.
- V. A continuous spectrum.—Solid carbon.

Compounds—

- VI. The alkaline earths, carbonates, and sulphates emit beautiful spectra of bands with lines. The oxides of the heavy metals such as iron, manganese, chromium, also behave in a similar manner. The bands of magnesium oxide and of manganese oxide are quite remarkable. Phosphoric anhydride emits a spectrum of a continuous band of rays with what appear to be very faint lines overlapping it. These are probably feeble indications of the edges of bands in the spectrum.

The spectrum of the Bessemer blow may best be studied with the aid of photographs :—

- 1st. By observing the spectrum as a whole, that is to say from the commencement to the termination of the blow.
- 2nd. By dividing the observations into definite periods, such as the slag forming, the boil, and the fining stage.
- 3rd. By dividing the long periods into shorter ones and studying the differences between them.

The first series of spectra ever photographed from the blow was shown upon the screen (Fig. 15); then the second series giving—(a) the spectrum during the slag period; (b) the spectrum during the boil; (c) that of the fining stage; and (d) the spectrum of the blaze seen when spiegeleisen is added, was also shown (Fig. 16).

The slag period shows little or nothing

beyond a slight continuous spectrum. Then the sodium yellow lines, the red lithium, and the red potassium lines become visible. After that bands appear in the green more or less degraded towards the red, and stronger the more manganese is present.

Half-way between the ends of the spectrum is a strong group of lines which divide those to the left hand which are visible to the eye from those on the right, the ultra-violet which are invisible. Observe how the bands increase in strength as the boil proceeds, and how much stronger they become until nearly the time when the flame drops they begin to fade. The same is to be observed also with the lines, which in the ultra-violet are nearly all due to iron. As to the blaze of spiegeleisen at the finish you will see that lines of manganese and potassium in the centre of the spectrum are exhibited, and there is either nothing more, or only one or two weak bands of manganese in the yellowish green region on the left.

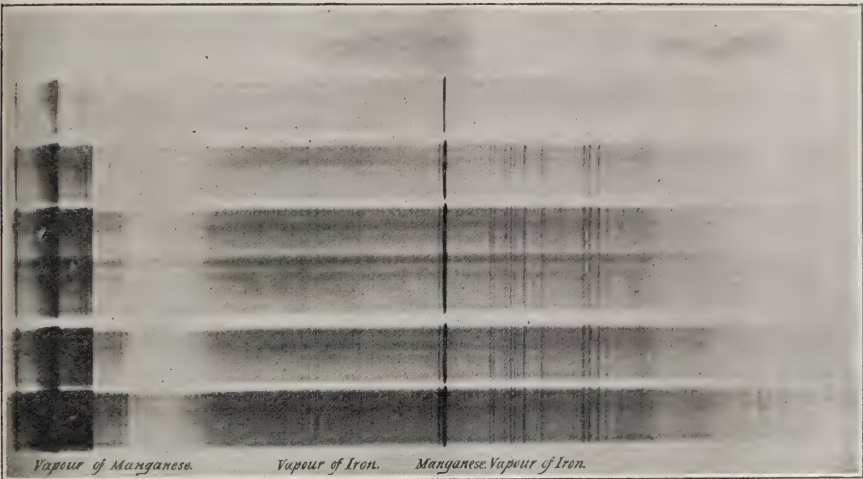
Taking a whole blow from beginning to end in two minute periods, or half minute periods, we see precisely the same phenomena, increase of temperature in the progress of the boil, with increased number and intensity of the lines and bands.

Spectra however differ not only with the metal blown in different works, but even with the same metal during different blows, according to the composition in the first case, and to the temperature in the second. But besides these variations there are certain broad facts which call for explanation. First, what is the nature of the flame? In the first, or slag-forming period, as we have seen, the silicon united with the manganese is oxidised to a manganese silicate, and carbon in the metallic carbides is oxidised to carbon dioxide, hence either no flame or very little.

In the "boil" when iron is being burnt to Fe_3O_4 , and then reduced by the action of Fe_3C (ferrous carbide), the carbon monoxide gas is evolved from the bath of metal, and it comes off violently, its evolution causes what is apparently violent ebullition, and the metal is at a high temperature from the heat developed by the burning of the silicon, which does not pass away like a gas, and so carry off its heat.

Now the carbon monoxide rushing from the converter is hot, and thus catches fire in the air; along with the carbon monoxide gas the vapours of manganese and iron are present, and these, which are carried out of the vessel in the reducing atmosphere of gas, burn to oxides. It must be mentioned that at a high

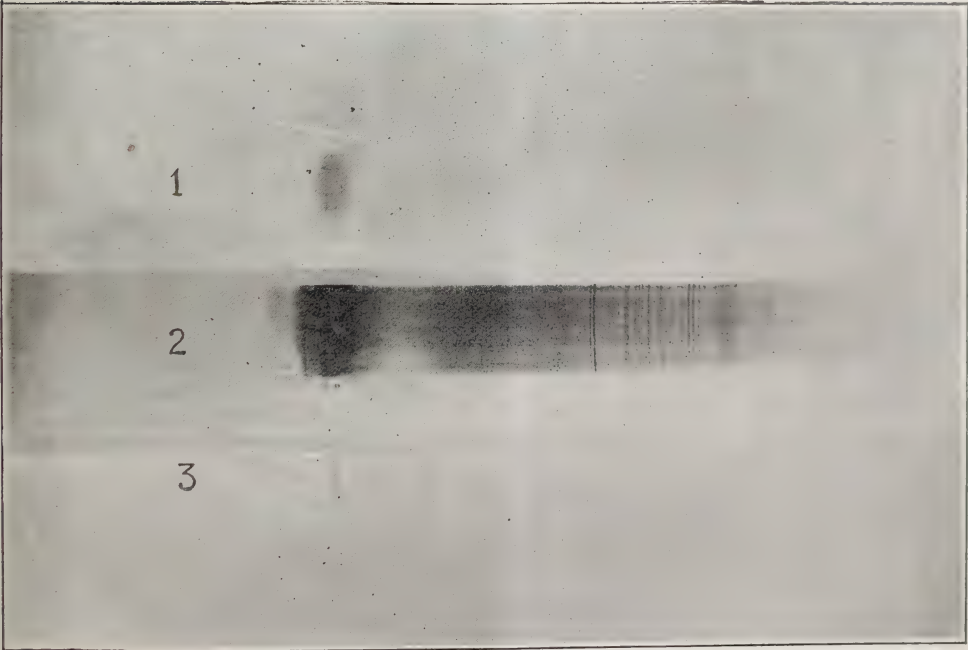
FIG. 15.



SEVEN SPECTRA TAKEN AT INTERVALS OF TWO MINUTES DURING THE WHOLE COURSE OF A "BLOW."

In the first or slag period, the lines of maganese are alone visible. In the second, the lines and some bands of manganese and the yellow line of sodium are visible. After the second period, the change in the spectra, caused by rise of temperature is readily seen, the lines of iron and the bands of manganese become more numerous.

FIG. 16.



SPECTRUM DURING (1) THE SLAG PERIOD; (2) THE "BOIL;" (3) THE BLAZE OF SPIEGELEISEN.

temperature, and in presence of metallic iron, Sir I. Lowthian Bell has shown that carbon monoxide is a more stable substance than the dioxide.

In the third or "firing stage," the last portions of the impurities are removed, such as carbon and manganese, and the flame gets more transparent, it carries less of the metallic vapour, and finally drops within the vessel. It shows diminished intensity if the lines in the spectrum are observed, for they are shorter and less strong, as well as less numerous.

When a converter is being turned down, the oxygen from the twyers burns the metallic vapours within the vessel and blows them out as a dense cloud of oxides. A similar action somewhat prolonged is seen in the over-blow of the basic process.

An illustration of this was shown, being a photograph of an actual blow taken instantaneously. It would take too long to enter into particulars of different spectra observed, but the following summary may be taken as a general description:—

During the first period.—Slag-forming.

The lines of the alkali metals, *sodium*, *potassium*, and *lithium*, are seen unreversed on a *bright continuous spectrum of carbon monoxide*. The C line of *hydrogen*, and apparently the F line, were once seen reversed during a snowstorm.

During the second period.—The "boil."

Bands of *manganese* are prominent, overlying the *continuous spectrum of carbon monoxide*. There are lines of *carbon*, *manganese*, and *iron*; also those of the *alkali metals*.

During the third period.—The "fining stage."

The spectrum is the same as the foregoing, but the lines of *iron* are not so strong and not quite so well defined. Some of the short lines disappear. The lines of the *alkali metals* are visible.

The curves reduced from Kupelwieser's analyses may here be referred to because they deal with a highly manganiferous iron containing much carbon and silicon. Here we have manganese oxidised from the first at a low temperature comparatively; the silicon is also oxidised and a slag is formed. The combined carbon, the silicon, and the manganese are *oxidised together* during the "boil," when the temperature rapidly rises, that is to say manganese carbide and silicide are being oxidised, not from carbon or free silicon, hence both in the slag-forming period and during the "boil" it appears as if these elements were being oxidised *side by side*, and at the same rate. The rise of temperature is rapid and the effect of this is to volatilise both manganese

and iron, and the gas of the converter constituting a hot reducing atmosphere carries the metallic vapours out of the converter, so that they are burnt in air along with the carbonic oxide. Towards the close of the "fining stage" the manganese in the fume is reduced in quantity and the iron is increased; accordingly in photographs of the spectra at this stage the manganese bands and lines diminish, and the iron lines increase in intensity. Suddenly the iron spectrum also becomes enfeebled and the "blow" is stopped. Without doubt at this point there is a very rapid diminution of temperature in the flame and in the bath, because the only combustible material left is iron, and its heat of combination is comparatively small.

The Bessemer flame is not the result of combustible gases and vapours being mixed with oxygen and burning within the converter, and thus, in a state of combustion, issuing into the air; but, on the contrary, it is carbonic oxide mixed with metallic vapours at an exceedingly high temperature burning outside the converter in a cold atmosphere. To imagine that complete combustion takes place within the converter would be quite erroneous.

In the over-blow or phosphorus period we have combustion taking place inside the converter, a flame extends outside, and a dense and copious fume arises from the oxidation of the iron.

The number of lines and bands belonging to iron and manganese which have been photographed in the Bessemer flame indicate that the temperature must be a near approach to that of the oxyhydrogen blow-pipe flame, if indeed it does not generally exceed it.

The parallel columns below show the number of lines observed in the spectra of the respective substances under different conditions:—

<i>Bessemer flame.</i>	<i>Carbon monoxide burnt with oxygen.</i>
CO spectrum,* 8 lines and edges of bands due to carbon. Exposure $1\frac{1}{2}$ to 3 minutes.	CO spectrum,* 16 lines and edges of bands due to carbon. Exposure 60 minutes.
	<i>Oxyhydrogen blow-pipe flame.</i>
Mn spectrum, 73 lines and edges of bands. Exposure $\frac{1}{2}$ to 3 minutes.	Mn spectrum, pure metal, 103 lines and edges of bands.
Fe spectrum, 92 lines. Exposure $\frac{1}{2}$ to 3 minutes.	Fe spectrum, 92 lines. Exposure from 15 to 30 minutes.

* I have more recently proved that the spectrum of carbon monoxide is a continuous band of rays, the lines and edges of bands sometimes seen in the spectrum are due to other carbon compounds or to carbon itself which is blown into the flame.—W.N.H.

The temperature is to be judged by the iron lines, because there is a smaller difference in the proportion of this metal present in the two cases than in the case of the carbonic oxide and manganese.

There is one point which remains to be explained, namely, the fact that the spectrum of manganese appears at times at the edge of the flame only where it touches the mouth of the vessels. The spectrum of manganese has been observed when there was no metal contained in it, but an old converter was being simply warmed with coke placed inside it, which was being burnt by the blast. A new converter in the same circumstances gave no indication of manganese.* This is owing to the fact that manganese is easily volatilised from the slag in sufficient quantity to colour the flame, just as potassium, lithium and sodium are. Accordingly by heating a piece of Bessemer slag in the oxyhydrogen blow-pipe the yellowish green flame of manganese is strongly, even intensely, visible. The mouth of an old converter is thickly coated with slag, and the flame volatilises the manganese from it.

But a few words more on this subject; you will see in what a very simple manner the spectra of most mineral substances are obtained. I take one gramme weight of strontium carbonate, barium sulphate, ferromanganese, manganese sulphate, or copper oxide, and by cutting an ashless filter paper in two I divide the gramme between the two pieces and roll them up tightly into the thickness of a quill, the mineral being inside the roll. By burning them in the oxyhydrogen flame an intensely brilliant colour is seen in each case from which a photograph can be taken of the spectrum of each substance. In our search after the origin of certain lines seen in seventy spectra of the "basic blow" photographed at the North Eastern Company's Steel Works at Middlesbrough, Mr. Ramage and I made use of this method to analyse the metal, ore, and limestone. The lines in question were identified in the steel rails, the blast-furnace iron, and in the ore. They were absent from the fuel and the basic material.

The lines in question belong to the metals potassium, rubidium, calcium, gallium, lead, copper, and silver. We next examined a hundred and ninety iron ores, and found these elements of very frequent occurrence. We

have also found these metals in meteoric irons along with nickel and cobalt.

It is a far cry from the blazing mouth of a Bessemervessel at Middlesbrough to the centre of the solar system, nevertheless, the single line of gallium recognised in the spectrum of the flame has carried us thus far, and within the last fortnight we have concluded from experimental evidence carried out with very perfect and elaborate instruments that gallium is an element present in the sun. This of course has nothing whatever to do with the Bessemer process.*

These are lectures on the chemical technology of a highly technical subject, but let me add that technical problems are nothing more than highly scientific problems, the solutions of which are directed and circumscribed by economic exigencies and commercial considerations. Look at the matter in what light you may, no real advance can be made if enormous manufacturing operations are conducted empirically and without the aid of scientific research.†

CORRECTIONS.—Page 724, Table of "Heat of Formation of Compounds," line 8, *for* Mn_3 (precipitated) *read* MnS (precipitated); line 16, *for* $CaSiO_2$ *read* $CaSiO_3$.

Correspondence.

PARLIAMENTARY RETURN OF SECONDARY AND OTHER SCHOOLS.

Mr. Brereton entirely changes his line of attack. A fortnight ago he told your readers that Mr. Sadler's return excluded "technical" schools. I proved that as the 50 schools founded under the Technical Instruction Acts were included "in the pale," it did nothing of the sort in any legal sense. He now says it is the law which is wrong. This is of course a matter of opinion. But the legal definition of Technical Education as covering these Secondary Schools was good enough for the late Royal Commission, for the authors of the Welsh Intermediate Education Act, and for her Majesty's Government in their Bill of 1896. Hence I fear it must suffice for myself and others with practical experience in organising English Secondary Education.

H. MACAN.

* Paper read March 16th, 1898. "A Determination of the Wave-lengths of the Principal Lines in the Spectrum of Gallium, showing their identity with two lines in the Solar Spectrum." By W. N. Hartley, F.R.S., and Hugh Ramage, A.R.C.Sc.I., Scientific Trans. Roy. Dublin Society, vol. vii., p. 1. 1898.

† A list of memoirs relating to the Bessemer process will be published in the next number of the *Journal*.

* Hartley. "Flame Spectra at High Temperatures." Parts I, II. and III. Phil. Trans., vol. 185, p. 161, p. 1029, and p. 1041. 1891.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Proceedings of the Society.

CANTOR LECTURES.

SOURCES OF COMMERCIAL INDIA-RUBBER.

BY DR. D. MORRIS, M.A., C.M.G.

Lecture I.—Delivered April 18, 1898.

INTRODUCTION.

India-rubber and gutta-percha are closely allied substances, not only in their origin but also in their chemical composition. They are both obtained from the latex of certain plants, and are composed wholly of carbon and hydrogen. Their similarity however ends here. The most conspicuous property of gutta-percha, as shown by Dr. Obach in the interesting lectures lately delivered before this Society, is that of becoming soft and plastic on immersion in hot water, retaining any shape then given to it on cooling when it becomes hard and rigid. Caoutchouc, on the other hand, does not soften in moderate heat, is impervious to water, alcohol, most acids, and gases, and retains for a long period its original elasticity and strength. Again, gutta-percha is obtained only from large trees belonging to one family of plants, the *Sapotaceæ*, confined to one small portion of the world's surface. Caoutchouc, on the other hand, is obtained from numerous families of plants, and these are distributed over almost every part of the tropical regions. These may be low herbaceous plants, shrubby climbers, small trees or majestic giants of the forest, 150 to 180 feet high.

About eighteen years ago six lectures on "India-rubber and Gutta-percha Industries" were delivered before the Society of Arts by Mr. Thomas Bolas, F.C.S. (*Journ. Soc. of Arts*, vol. xxviii. (1880), pp. 753-813). With the exception of the earlier part of the first, the whole of these interesting lectures was

devoted to the chemical and physical properties of rubber and to the various processes of manufacture adopted in this country.

As indicated in the title, the present lectures will cover only a limited part of a very wide subject. In fact they will be confined to an investigation of the rubber plants now existing in various parts of the tropics, their geographical distribution, the conditions under which they grow, and the prospects they afford of being able to meet the increasing demand for rubber. This, it is admitted, is a subject of engrossing interest at the present time.

HISTORY.

The first record of india-rubber was made soon after the discovery of the New World by Columbus. The Old World rubbers were still unknown. During the second voyage of Columbus, it was noticed that the inhabitants of Hispaniola (Hayti) played with balls made from the gum of a tree. This was just 400 years ago. Torquemada mentions for the first time the name of a rubber tree. That was the ul tree of Mexico—the tree we now know as *Castilloa elastica*, yielding Central American rubber. It is a singular fact that in the depths of the Guiana forests, in the remote Indian villages on the tributaries of the Amazon, and in the heart of Africa, similar rubber balls are still being used to play with. Often it is only in this way that travellers have become acquainted with the existence of rubber-yielding trees in the vicinity.

La Condamine, who was sent in 1735, by the French Government on a scientific mission to Quito, gave the first accurate information concerning the tree yielding the Para rubber; while other French travellers, Fresneau and Aublet, described the trees yielding caoutchouc in the forests of French Guiana.

India-rubber was not known in any part of Asia until 1798, when Howison, a surgeon at Prince of Wales Island, discovered the plant we now know as *Urceola elastica*. Towards the close of 1810, Mr. Smith, of Sylhet, enabled Roxburgh to trace the Assam rubber tree (*Ficus elastica*).

The use of rubber for articles of domestic utility was practised by the natives of Central and South America, and by the tribes inhabiting Assam, long before it was known to European nations. Ernst states that the "Cambibas, a section of the tribe Amaguas on the Upper Amazon, used rubber juice in pre-Columbian times to make waterproof vessels for carrying food and water, giving it the

name of *caucho*, no doubt the original of our word caoutchouc." Further, it is related that in 1755 the King of Portugal, Don José, having heard of the wonderful waterproof materials used by the Indians, "sent several pairs of his Royal boots to Para in order that they might be covered with rubber." The earliest use of caoutchouc or elastic gum in this country was for rubbing out pencil marks, hence "india-rubber." It was, however, a mere curiosity, and valued at the end of the 18th century at 3s. the cubic half inch.

Although used in moderate quantities in the early part of this century in the pure state for flexible tubes for surgeons and chemists, and afterwards for waterproofing by the method applied by Charles Macintosh, it was not until about 1874, through the discovery of vulcanising rubber by the admixture of sulphur by Good-year in America and Thomas Hancock in this country, that india-rubber became an article in extensive use in the arts and manufactures. Later was introduced the hard vulcanised rubber, termed vulcanite and sometimes ebonite. This opened up a still wider field of usefulness, as in this form india-rubber became a substitute for such materials as horn, bone, ivory, and jet.

The extensive use of india-rubber in this country has almost entirely arisen during the Victorian period. The rapid progress of the rubber industry may be illustrated by the following Table :—

Imports into England.

Year.	Tons.
1830	23
1840	334
1850	381
1870	7,606
1879	7,530
1888	11,018
1897	19,816

It will be noticed that while about the time of the Queen's accession the imports of rubber into this country were only about 200 tons, they have now increased to a total amount of 20,000 tons—exactly a hundredfold.

In regard to the gross value of the turn-over in the rubber trade, the figures for the year 1896 are as follows :—

Imports of raw india-rubber	£ 4,990,122
Re-exports	2,643,782
Export of manufactures of caoutchouc	1,261,774
Total trade, ...	£8,895,678

It is interesting to notice that of the total imports into the United Kingdom, there has been during the last eight years a very considerable increase in the quantity of rubber imported from British possessions. This is illustrated in the following Table :—

Total Imports of Caoutchouc into the United Kingdom, distinguishing between those from Foreign Countries and British Possessions.

	1888.		1896.	
	Tons.	Value £	Tons.	Value £
Foreign countries	8,509	2,132,662	15,465	3,956,126
British possessions.....	2,509	422,679	6,093	1,034,996
Total...	11,018	2,555,341	21,558	4,991,122

TOTAL TRADE.

The principal European countries together with the United States of America at present import caoutchouc to the following approximate amount and value :—

Countries.	Years.	Quantity.	Value.
		Tons.	£
Great Britain . . .	1896	21,558	4,991,122
France.....	1896	5,177	1,111,256
Germany.....	1897	8,436	2,320,150
Belgium	1897	2,236	545,835
Holland	1897	1,672	141,667
Austria-Hungary.	1897	2,109	811,415
U.S. America ..	1897	18,821	4,514,587
Total		60,009	14,436,032

The world's consumption of raw india-rubber may therefore be placed at about 60,000 tons annually, of the value of about £15,000,000 sterling. It must be remembered, however, that a large quantity of reclaimed rubber and artificial substitutes are being used, and that so-called rubber goods may contain but a small proportion of genuine rubber.

USES OF RUBBER.

It is needless to enlarge upon the numerous purposes for which india-rubber is now utilised. Steam power everywhere, whether on land or sea, requires the use of rubber for valves and pumps, for hose and tubing ; it is also essential for telegraphy and water-proofing, life-saving apparatus, surgical instruments, innumerable domestic appliances, the manufacture of ebonite articles, and more recently in the extraordinary development of the cycling trade, these and like services ministering to the daily necessities

of all civilised communities demand an enormous supply of raw india-rubber—in fact a large proportion of the arts and manufactures of the world may be said now to depend on the continued supply of this interesting substance. It can, therefore, be imagined that owing to the increasing demand for india-rubber and the enormous number of uses to which it is put the question of securing the permanency of an adequate supply is a very important one.

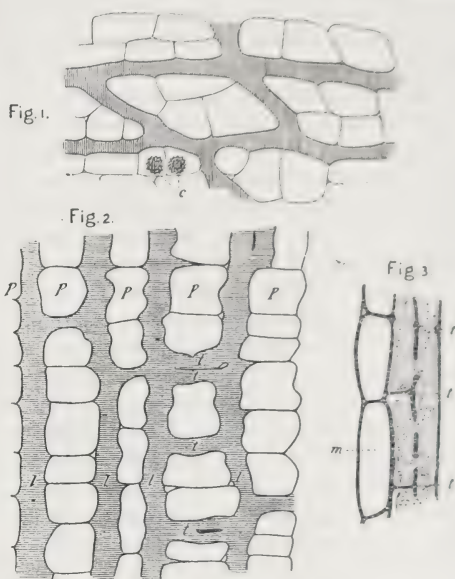
It has been suggested that owing to the considerable destruction of rubber trees going on in various parts of the world the india-rubber industry may be retarded owing to the scarcity of the raw material. The great and growing use for india-rubber has evidently stimulated the rubber collectors, and in their eagerness to meet the demand they destroy a great number of the trees. In some countries this has undoubtedly led to the exhaustion of certain localities, and the rubber gatherers have to go farther inland whereby the danger to life and the cost of transit are greatly increased. This is probably true of many parts of Mexico and Central America, and also of the East and West Coasts of Africa. So far it cannot be said to be true of the vast Amazonian region, and this at present produces not only the best class of rubber but more than one-third of the world's supply.

LATEX IN PLANTS.

The rubber milk found in certain plants is an aqueous fluid charged with soluble substances, in which float minute globules of caoutchouc. From the difference of the refractive powers of these two substances we have the milkiess of the juice. This juice is quite distinct from the sap. It is, in fact, a secretion, and apparently not essential to the life of the plant. It is conceivable, therefore, if this juice were removed in moderate and regular quantities, without seriously wounding the tissues, that the plant would not materially suffer. It is necessary, however, to make some incisions to obtain a flow of milk. What is required is a process whereby the largest quantity of milk is obtained with the minimum amount of actual injury to the plant itself.

The vessels in which the milk or latex is contained are generally found in the inner layers of the bark. They form a complicated system of communicating passages filled with latex; they are most abundant in the older tissues, and gradually spreading to the leaves and flowers. Usually in such plants as *Manihot* and *Hevea* there is a scanty system of

laticiferous vessels in the outer bark, but they are most abundant in the inner bark next to the cambium region. This latter circumstance accounts for the injury often done to the trees in the unskilful attempts made to reach the inner laticiferous vessels. There is no milk obtainable from the wood. There is, therefore, no advantage in making incisions further than the inner bark. Anything further causes injury to the tree, and destroys its productiveness. The latex when first obtained is of a creamy consistency and colour. In some cases,



LATICIFEROUS TISSUE OF *Manihot Glaziovii*.
(After D. H. Scott.)

Fig. 1. Hypodermal laticiferous tissue from young stem. (*c*) Crystals of calcium oxalate.

Fig. 2. Laticiferous tissue from primary phloem $\times 270$. (*l*) Laticiferous vessels; (*t*) their transverse connecting branches; (*p*) parenchyma.

Fig. 3. Portions of young laticiferous vessels $\times 160$.

as in *Hevea* and in *Hancornia*, it is of a slightly pinkish colour, due to a colouring matter in the young bark. Besides the globules of caoutchouc, the latex contains certain salts and albumen. When the fresh juice is exposed to the air in thin films, it speedily dries and hardens into elastic layers of brownish yellow caoutchouc. It is evident that the caoutchouc is not dissolved in the juice, for when the latex is diluted with water it rises to the surface like cream, and when once it has become coherent it cannot again be diffused.

Chemically the latex is a very complex fluid containing, besides proteids, a considerable quantity of caoutchouc and resinous matters. The latter are very variable in amount, but in

some sorts of latex, viz., those yielding the best rubber, they are almost entirely absent. Further, it is uncertain whether the body or bodies we call caoutchouc are the sole constituents of the granules, or whether these each consist of a mixture of different substances. Thus, in some measure at least, arise the numerous sorts and qualities of rubber, apart from the methods adopted in their preparation.

COAGULATION OF RUBBER MILK.

The methods of coagulating rubber—that is of extracting the globules of caoutchouc from the milk in which they float—varies in every country and in almost every district in which rubber plants are found. So far these methods are the crude hereditary arts of a semi-savage people who have adopted the most wasteful methods simply because of their convenience to themselves. None of these methods are based, as they should be, on scientific principles. In the course of our study of the rubber industry in different parts of the world we shall pass in review the various methods adopted for coagulating rubber. Some of them are very singular. In Fiji the milk is taken in the mouth and the small pellets thus formed are eventually worked up by hand into balls the size of cricket balls. In Africa and in New Guinea the natives smear their bodies with the milk and afterwards peel off the layer of caoutchouc dried on the skin and either cut it into small cubes or press it into slabs. A favourite but a wasteful method is to allow the milk to run into holes in the ground, and when the watery parts have drained away there is left a spongy mass of caoutchouc mixed with dirt and leaves. This has been the practice in parts of Central America and in Assam. The use of salt water to form a milk clot is adopted in Borneo, Africa, and some parts of Eastern Brazil. Alum is also used as well as the juices of certain plants. Boiling the milk, or at least heating it, is a favourite method in Lagos and the Congo State, while in the Amazon valley the smoke of a smouldering fire, combined with moderate heat, is the almost universal method of preparing Para rubber.

In a few cases the milk is allowed to dry as it trickles down the stem of the tree and thus is obtained the scrap rubber in Ceara and a good deal of the rubber shipped from Assam and Penang.

Where the milk is obtainable in quantity, as in the case of the Para and Central American rubber trees, and can be collected in vessels holding a gallon or two there is available a

mechanical method for extracting the rubber which is likely to be of considerable value. Briefly stated the principle is almost identical with that of the cream separator. It is the invention of Messrs. Howard and Biffen, who have carefully tested the plan in the rubber-producing countries of the new world.

NEW PROCESS FOR COAGULATING RUBBER MILK.

In this method the latex, after being mixed with 50 per cent. of water, is placed in the machine and spun for the space of a few minutes. The machine is then allowed to come to rest gradually, when the rubber is found floating on the top of the liquid in a thick white mass. The albuminoids, proteids, and all dirt and chips are found at the bottom. The rubber is skimmed off and placed to drain on a porous surface. According to experiments carried on by Mr. Hart in Trinidad, it can be removed in about two hours, and in six hours afterwards it is comparatively dry.

The advantages of this method of extracting caoutchouc are as follows:—

- (1.) It produces absolutely pure rubber.
- (2.) The whole process is under scientific control.
- (3.) It is capable of dealing efficiently and immediately with any quantity of milk.

Those interested in the study of the scientific treatment of the milky juices of plants, cannot do better than obtain a copy of a very interesting and suggestive paper on “The Coagulation of Latex,” contributed by Mr. R. H. Biffen, B.A., to the “Annals of Botany,” vol. xii. (June, 1898), pp. 165-171. In this Mr. Biffen gives the result of observations made on the latex of nearly all the rubber-yielding plants of the New World. His own account of the application of the centrifugal method for the purpose of coagulating the latex is as follows:—

“As the rubber exists in particles in the latex, it seemed possible that the centrifugal method of separation might be adopted in examining the phenomena of coagulation. A modified form of the ordinary centrifugal milk-tester was therefore designed capable of being rotated some 6,000 times per minute. The latex was taken directly from the trees, strained through wire gauze to remove any pieces of bark, and then, if very thick, diluted to about the consistency of thin cream. The first experiments were made with the latex of *Castilloa elastica*. After centrifugalising for from three to four minutes, the rubber particles completely separated as a thick

creamy white layer from the deep brown solution, containing tannic acid, in which they had been suspended. This layer was now taken off, shaken with an excess of water to thoroughly wash it, and again separated. The separated particles were then shaken with water so as to form an emulsion, and alkalis were added. No coagulation now occurred, even though the mixture was allowed to stand for several days. The particles could, however, be brought into a solid mass by pressure, by gentle heating, or by drying off the water with a porous tile. So prepared, the rubber formed a pure white mass, without any trace of its usually characteristic smell. On exposure to the air for several days, the surface gradually became brown, probably owing to oxidation. The per-centage of rubber in the latex was estimated at 25 per cent. The latex of *Hevea brasiliensis* was similarly treated, but for a slightly longer time; the yield of rubber in this case was from 28 to 30 per cent."

FORMS OF COMMERCIAL RUBBER.

The earliest and best known forms of rubber were the biscuit and bottle rubber, obtained from South America. These yielded the old rubber first used for rubbing out pencil marks—black outside, lighter within, and possessing a characteristic smoky odour. The "fine Para" of the present day is still the best rubber in commerce. Similar rubber is also obtained from Peru, Bolivia, and Venezuela. The produce of *Castilloa* trees in the Central American States is variously known as Nicaragua, West India, Honduras, Mexican, Guatemala, Panama, and Peruvian "Caucho," according to the locality from which it is obtained. The rubber comes in blocks, sheets, or scraps; is uniformly black, not unfrequently tarry or sticky on the outside, and usually obtains prices about two-thirds of that of the best Para.

Ceara rubber is a dry rubber, very elastic and free from stickiness; the milk coagulates in tears on the trees, and forms "scrap" or strings made into balls or packed loosely in bags.

Pernambuco or Mangebeira rubber is often coagulated with salt, and is a "wet" rubber. It occurs in biscuits or sheets, and is also obtained from Bahia, Southern Matto Grosso, and Uruguay.

African rubbers are produced throughout the whole of tropical Africa. The sorts are numerous and the distinctive names, descriptive and geographical, are almost endless. The following are the principal varieties produced on the West Coast:—Gambia, Sierra Leone, Lagos, Gold Coast, Congo ball, Thimbles, Calabar,

Cameroon, Batanga, Liberian. On the East Coast are produced Mozambique ball, Sausage, liver, unripe; Madagascar, good and fine, and Madagascar black.

The Asiatic rubbers from Assam and Rangoon are mostly scrap rubber formed into cakes, slabs, and loaves. The rubber is always of a mottled appearance with bright pink streaks. Java is somewhat similar but usually not so good. Bornean rubber is in balls or shapeless masses of a white or purplish colour, very spongy and porous. One of the latest additions to the list of commercial rubbers is New Guinea rubber. This comes in the form of clusters of small balls, black outside, whitish within. When free from bark and impurities it is of good quality. Sometimes a bastard sort is shipped, whitish and hard, almost resembling Balata.

As might be expected from the opening up of new sources of supply, and the greed of the collectors, the india-rubber now imported is a much more variable article than formerly. Probably less care is taken in preparing the rubber and the latex from different plants, varying in quality and composition, are unskillfully mixed together. The result is that manufacturers are chary of new sorts, and are driven to confine their attention to a few well-known rubbers, such as Para, Mozambique, and Madagascar, which in the best qualities are of a dependable character.

CLASSIFICATION OF RUBBER-YIELDING PLANTS.

There are several hundred plants with a milky juice, but, so far, less than fifty of these contain sufficient caoutchouc to repay the cost of extraction. The plants now yielding commercial rubber may be grouped under four natural orders as follows:—

RUBBER-PRODUCING PLANTS.

	Species.
I. Spurges (<i>Euphorbiaceæ</i>)	14
II. Nettles (<i>Urticaceæ</i>)	4
III. Dogbanes (<i>Apocynaceæ</i>)	27
IV. Asclepiads (<i>Asclepiadaceæ</i>)	1
Total	46

I. EUPHORBIAEÆ (Tribe: *Crotoneæ*).

Genera.	No. of Species.	Country.	Product.
<i>Hevea</i> ...	10	Brazil.	Para rubber.
<i>Manihot</i> ...	1	N.E. Brazil.	Ceara rubber.
<i>Micrandra</i>	2	Central Brazil	Amazon rubber (in part).
<i>Sapium</i> ...	1	U.S. Colombia	Colombian Virgin rubber.

II. URTICACEÆ (Tribe: *Artocarpææ*).

Genera.	No. of Species.	Country.	Product.
<i>Ficus</i>	2	East Indies.	Assam & Rangoon rubber.
<i>Castilloa</i> ..	2	Cen. America	Central America rubber.

III. APOCYNACEÆ.

Genera.	No. of Species.	Country.	Product.
Tribe, <i>Carisseæ</i>			
<i>Hancornia</i> ...	1	Brazil	Mangebeira rubber.
<i>Landolphia</i> ..	10	Tropical Africa	African rubber.
<i>Carpodinus</i> ...	6	W. Central Africa	Kwango rubber
<i>Leuconotis</i> ...	2	Malaya	Borneo rubber.
<i>Willughbeia</i> ..	2	Malaya	Borneo rubber.
Tribe, <i>Echitideæ</i>			
<i>Kickxia</i>	1	West Africa	Lagos silk rubber.
<i>Urceola</i>	2	East Indies	Burma rubber (in part).
<i>Forsteronia</i> ...	2	Tropical America	Guiana and Jamaica rubber.
<i>Parameria</i> ...	1	East Indies	East India rubber (in part).

IV. ASCLEPIADACEÆ (Tribe: *Periploceæ*).

Genus.	No. of Species.	Country.	Product.
<i>Cryptostegia</i>	1	Madagascar	Pulayrubber (India)

PARA RUBBER.

Para rubber derives its name from the town and province of that name in Brazil. It is rightly regarded as the most valuable of any in commerce. The price of Para rubber practically governs that of all other rubbers. The tree or trees, for probably more than one species is utilised, are distributed throughout the vast region of the Amazon valley and adjoining areas, and occupying an area about two-thirds the size of Europe. The principal tree yielding Para rubber is the "Seringa," *Hevea brasiliensis* (syn. *Siphonia brasiliensis*), belonging to the natural order *Euphorbiaceæ* or Spurges, numerous members of which secrete a milky juice. The tree is upright and grows to a large size, up to 60 feet in height with a trunk six to eight feet in circumference. The branches, when the trees grow closely together, are short; the leaves are compound and trifoliate. The whitish-green flowers are male and female in the same panicle, the female usually larger and terminal. The fruit is a large dry capsule

composed of three one-seeded pieces. The seeds are the size of filberts with a shining seed coat marked with black blotches; the interior substance is very oily. On this account the seeds soon lose their vitality. In the Lower Amazon valley the trees flower in January and February, and the seeds ripen at the beginning of the dry season, in July and August.



FIG. 4.—BRANCH OF PARA RUBBER (*Hevea brasiliensis*).

Shewing trifoliate leaves and numerous small flowers. The female flowers are larger and terminal. The capsule (7) is cut open to show position of seeds, usually three in number. Seed (8) is one-half natural size.

Seeds.—The seeds of *Hevea* are said to be used locally for baiting fish, and also yield by expression an oil of a clear violet colour, not so siccative, according to Collins, as that of linseed oil, but said to be capable of use in the preparation of varnish. The wood is soft and soon decays.

The collection of seeds in the dense forests of Brazil is a matter of considerable difficulty. If gathered immediately they have fallen and carefully packed they should bear transport for a period of at least three weeks. They travel better packed in moderately dry soil or coconut fibre. Where obtainable, seeds from mature cultivated trees are preferable to seeds collected in Brazil, as they are more accessible and

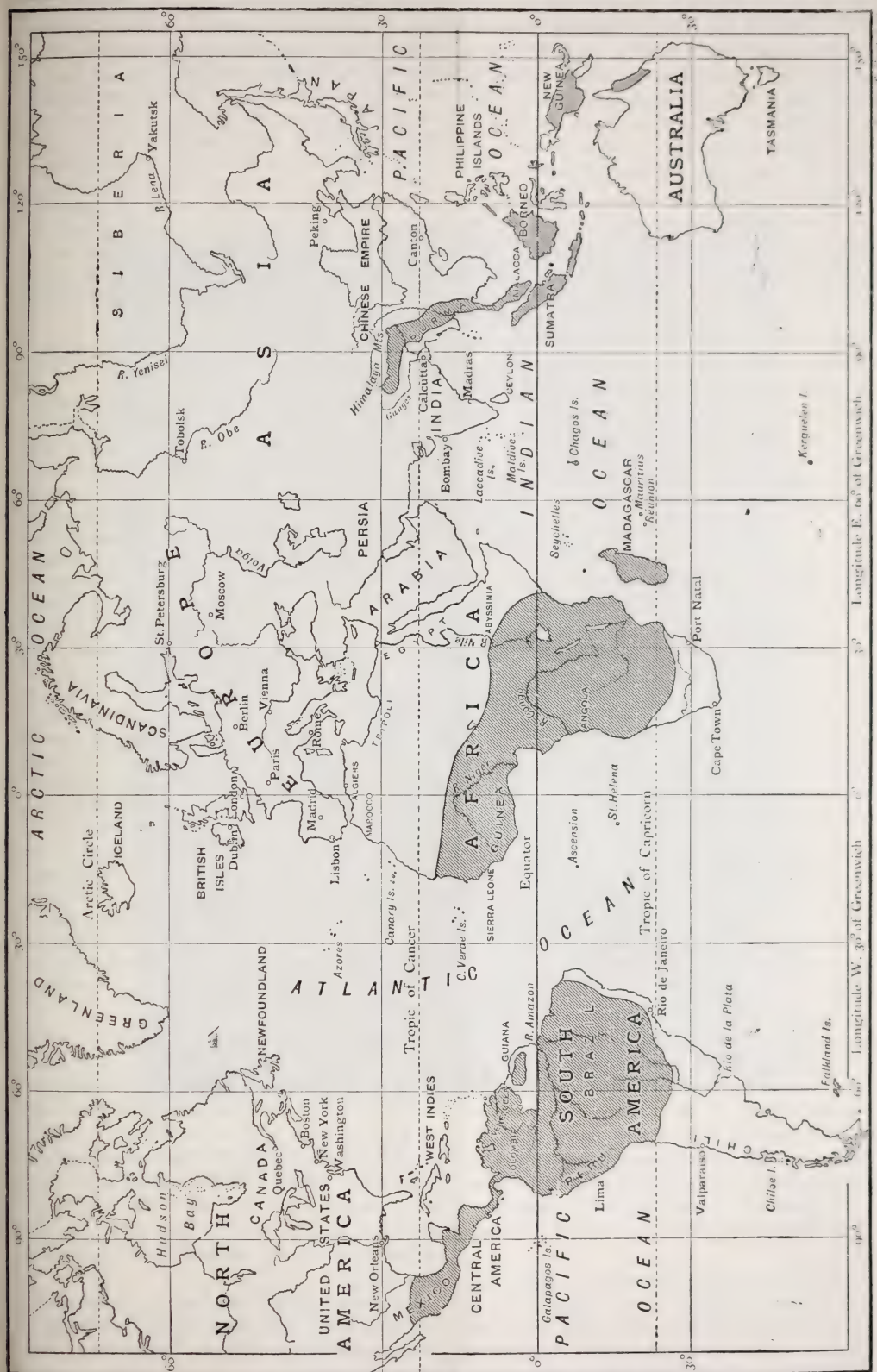


FIG. 5.—MAP OF THE WORLD ILLUSTRATING THE DISTRIBUTION OF RUBBER-PRODUCING PLANTS.

can be gathered immediately they ripen. Seeds forwarded from Ceylon to Kew, packed in canvas bags, have arrived in excellent condition. Where seeds are not obtainable plants may be raised from cuttings of the green shoots.

The species of Heveas recorded as yielding rubber in Brazil and adjoining countries, are as follows:—On the Rio Negro, *Hevea lutea* yields most milk, but is not regarded as so productive as *H. brasiliensis*. About the mouth of the Tapajos and Madeira, *H. spruceana* is most frequent. In Venezuela, *H. benthamiana* is probably found, while, in British Guiana, *H. pauciflora* is regarded as a valuable rubber tree.

Besides Heveas, it is possible, according to Spruce, that on the Purus and other remote tributaries of the Amazon, species of *Micrandra*, also called by the Indians Seringa, yield a pure rubber. Little is known of these latter trees.

Hevea brasiliensis grows in the moist, hot forests of the province of Para, and especially in the district near the numerous mouths of the Amazon, known as the islands. It probably extends far inland into the province of Amazonas, but its exact distribution is not clearly known. Other species of Heveas, eight or ten in all, are found not only in Brazil, but also in Venezuela, Guianas, Peru, and Bolivia.

The district where *Hevea brasiliensis* flourishes, is in S. lat. 1°; the climate is remarkable for its uniformity of temperature, usually not exceeding 87° Fahr. at mid-day, or below 74° at night. The greatest heat recorded is 95°, and the mean for the year is 81°. The rainfall occurs principally during the months of January to June, the maximum being in April, when it reaches 15 inches. For the remaining six months, little rain falls, but the air is always loaded with moisture. The whole country is covered with dense almost impenetrable forests, and the soil near the numerous and gigantic rivers is deep, heavy, and very fertile. Some of the low-lying country, where the rubber trees grow, is annually flooded, and is very damp and unhealthy. Under cultivation in Ceylon it has been found that the trees will also flourish on well-drained soils beyond the reach of floods.

Mr. Kerbey, the American Consul at Para, states:—

“The rubber tree thrives well both on high and low land; but in order to yield a large supply of milk it must have plenty of moisture in the soil part of the year at least. For example, on the river Purus, where the flood plains are covered with water from one to

three or four months in the year, the trees on these levels yield milk in abundance, while large trees of the same sort, not reached by the floods, do not pay for the trouble of tapping them. On the Lower Amazon not only the trees on the tide flats and annual flood plains yield milk in paying quantities, but also those on the high land (*terra firma*) because the rains of six months or more in the year supply abundance of water to the soil.” He continues, “The territory from which Para rubber is gathered is nearly or quite as extensive as all the United States lying east of the Rocky Mountains. Some of the Para rubber has to come as far to reach Para as it has to travel from Para to reach New York.”

Mr. Consul Churchill lately reported to the Foreign-office:—

“The *Hevea* tree is not conspicuous, and resembles many other forest trees. People have travelled for thousands of miles through the rubber region and have lived for years in the centres of the industry without even noticing it. The new-comer invariably expects to see the familiar glossy dark-green leaves of the *Ficus*, and is disappointed with the insignificant appearance of the *Hevea*. In appearance it is more like the English ash than anything else. It grows to a height of upwards of 60 feet. The leaves are trifoliate. The localities where rubber-trees thrive the best are on islands and low ground near rivers where the banks are periodically inundated. Ground that is above water at all times or that has no drainage is not suitable to the tree. A peculiarity of this rubber-tree is that it will not grow satisfactorily on cleared and open ground. It requires the shade of other trees and still air, from the time that its growth begins until it becomes an adult tree. Without these conditions the supply of milk is very much affected. In fact the tree has been known to die soon after the clearing of ground around it. No cultivation worth mentioning has been attempted in the Amazons region. It is considered useless to invest capital in cultivation so long as the Amazonian forests show no sign of exhaustion. The *Hevea* requires about 15 years to mature—that is too long for the ordinary investor to wait.”

Tapping.—The season for tapping the trees varies according to each district. It is usual to leave the trees untouched for a few months in the year, *i.e.*, from the period of flowering until the fruit has attained its full size. In the neighbourhood of Para the tapping universally takes place during the dry season from June to December. On the upper Rio Negro, as the trees flower earlier—November to the end of January—the tapping season is altered accordingly.

Trees are tapped if they have a circumference of eighteen to twenty-four inches. If the process is carefully carried on the trees may last for many years.



FIG. 6.—TAPPING TREES OF *Hevea Brasiliensis*.

The rugged, gnarled appearance of the stem is due to successive tappings causing thickening of the bark.

The methods employed in tapping and collecting the rubber in Brazil or elsewhere are of a rough and wasteful character. The actual collectors or *seringueiros* are a depressed class, entirely in the hands of traders, who in exchange for rubber supply them with food and other necessities. The collectors seldom do more than earn a bare subsistence.

The work of tapping begins at daybreak, as the milk is said then to flow more freely and in greater quantity. The tree is cut by striking in an upward direction with a small axe, making a deep incision through the bark. A small cup is immediately placed underneath, and held on by a small quantity of soft clay. Into this the milk slowly flows. At a short distance, but at the same height, another cut is made, and a similar cup is luted on, and so the process is continued until a row of cups encircle the tree at a height of about six feet from the ground. Tree after tree is treated in the same manner until the tapping for the day is finished at about 9 or 10 o'clock. The next morning the operation is performed in the same way, but the cuts are made from six to eight inches lower down the trunk. Thus each day the cuts are made lower and lower until the ground is reached.

On the Upper Amazon other methods for tapping are sometimes adopted. They are, however, only applicable where the trees have not been previously tapped. The loose outside bark is first cleaned off and the trunk made quite smooth to a height of three feet or more. Beneath this area a gutter or raised border of clay, resting upon the stout, flexible stems of a climber, is closely placed round so that no milk can escape between the trunk and the gutter. Cuts are thickly made in the bark above, from which the milk flows down to the gutter, whence it is conveyed into a calabash conveniently placed to receive it. By this method there is usually a considerable quantity of scrap rubber, owing to the distance the milk has to run and to the coagulation that takes place on the large surface of clay used.

Mr. Consul Kerbey states :—

"If but three gashes per day are made in bark of the rubber tree, and the hatchet in the careless hands of the native does not penetrate or strike the wood, the tree does not appear to suffer from the treatment, except that the trunk grows thick, and the scarred surface becomes irregular and bumpy. It will continue, however, in good health, and yield milk in abundance for thirty or forty years. If the blow from the hatchet, however, wounds in the slightest degree the wood of the tree, it dies. Decay begins at this

wound. As the wood is soft, a weevil enters the decayed spot, and hastens the destruction. The tree may drag out a miserable existence half dead, but, as the Portuguese say, it is *cancado*."

Collecting the Milk.—Where cups are used, the *seringueiro*, at the close of each day, goes from tree to tree at a sort of running pace; he empties the contents of the cups into a large calabash which he carries in his hand. As he pours the milk out of each cup, he draws his thumb and forefinger over the bottom to clean out some which otherwise would adhere to it. The cups on being emptied are laid in a little heap at the base of each tree, to be ready for the following morning.

Preparing the rubber.—The preparation of the rubber is thus graphically described by Wells ("Voice of Urbano," pp. 119-120) :—

"Master and men then departed to various out-buildings, where the Indian boys and women, after partaking of a very hasty and meagre repast of dried *piraurucu* (a large river fish) and *farinha*, were set to work at converting the milk, or sap of the rubber-tree, into india-rubber.

"This process does not require any great manual labour; it is rather a work of patience. In a distant corner of the yard, under the shade of one of the few remaining trees, a quantity of the fruit of the *Urucuri* palm was burning on several fires. The burning of these nuts produces a dense black smoke, the acidulous properties of which has proved to be the most efficacious for rapidly coagulating the sap of the rubber-tree. Near each fire, one of the large earthenware pots was placed between a couple of Indian boys, each boy having a small round-bladed paddle in his hand; the blade of the paddle is dipped into the milk which, adhering to the wood, is held in the smoke of *Urucuri*, and rapidly coagulated, and turned almost at once to the black india-rubber of commerce. The round blade of the paddle, covered with a thin coating of rubber, is then again dipped into the pot of sap, and the process repeated and continued until the rubber is about two inches thick, when one of the attendant drivers, who superintends the operations, makes a cut with a sharp knife along the outer circumference of the paddle, when the round cake of rubber is easily removed, and then placed with others on the ground alongside the operator. So the process is continued until the collected sap is exhausted, and the rubber stored away.

"Early the next morning, the Indians will again go away in the canoes to the forest, there to empty out the contents of the tins that have been previously left adhering to the rubber trees by a dab of clay below a gash in the bark, whence the milk slowly drops into the tin pans. The pan, when emptied, is then replaced or affixed to another part of the trunk, or removed altogether to some other tree. It depends on the collector whether he completely exhausts the tree of its sap, and thus destroys it, or

only takes a quantity—about 16 lbs.—which a well-grown tree will allow to be taken from it without detriment. In the case of Ignacio's men, all the sap that it was possible to obtain was taken from every tree."

There are practically only two grades of Para rubber, viz., Fine Para and Negro-head. The former is a fine dry rubber, coagulated over smoke, of a dark colour and a characteristic odour. It appears in the form of biscuits or "hams." It is uniform in quality, and is the standard by which all other grades are tested. Negro-head is made up of rounded masses of uncured rubber, with sometimes flattened discs, the result of coagulation in the clay cups. On the outside this is rougher and darker than fine Para, arising from oxidation due to prolonged exposure to the atmosphere; the interior is almost white and cuts like fresh cheese. There is also an intermediate sort called medium, or *entrefine*, due to imperfect curing and the presence of strips of "virgin gum" between the layers.

Through the kindness of Dr. Obach, I am enabled to give an original illustration of the implements actually used in collecting and preparing Para rubber (Fig. 8). These are as follows:—

1. A small light axe with a cutting edge about one inch in width. This is used for making incisions in the bark.

2. Immediately under these incisions small earthenware or tin cups are placed to receive the milk. The three upper cups represented are of tin; the single one below is of earthenware. The former are preferred on account of their lightness.

3. The milk collected in the small cups is poured into a calabash or gourd. From this it is afterwards transferred into the large tin vessel on the extreme left (3a) and carried to the camp.

4. The large clay stove in the centre is used for curing the rubber. A fire is lighted underneath made of the nuts of the Urucuri palm (*Attalea excelsa*), shown at 5. The smoke escapes through the aperture at the top.

6. The heavy paddle is now dipped into a large bowl containing the day's gathering of milk and immediately placed in the smoke. The effect of the heat and smoke is to coagulate the milk and give it a dark colour. The process is repeated until a large cake is formed. The paddle is then released by making a slit on one side. The hook (6a) is used to support the paddle when in use by a rope from the roof of the hut.

According to Mr. Biffen, in the paper already cited, the latex of *Hevea brasiliensis* is alkaline, and the addition of a solution of ammonia preserves it indefinitely from spontaneous coagulation. The coagulation of the latex by exposing it to the smoke of the Urucuri nuts is doubtless brought about partly by heat and partly by the action of the acetic acid contained in it. The latter and the creosote also present further tend to preserve the rubber. The smoking process would appear to be only applicable in the case of latex possessing alkaline properties. It is unsuitable in the case of the latex of *Castilloa elastica*, as this has an acid re-action towards litmus paper; hence alkalies are used.

The yield of rubber would appear to vary from 2 or 3 lbs., up to 16 or 17 lbs. per tree. Large fully developed trees should yield 10 lbs. without injury each year, if carefully treated. Cultivated trees in the Straits Settlements have yielded at the rate of 5 lbs. per tree at 10 years old. Trees in Ceylon have yielded at an average yearly rate of 1½ lbs. per annum, after the eighth year. This is, of course, exceptionally low as compared with Brazilian trees, but where the trees are closely planted, the return may reach a rate of 100 lbs. per acre.

Out of a revenue of £428,894 collected on exports in State of Para in 1896-97, £415,295 was collected on rubber alone. The export duty is 23 per cent.

The entire Amazonian crop of 1895-96 amounted to 20,981 tons, whereas that of 1896-97 reached 22,315 tons, an increase of 6·4 per cent. The crop of the State of Para during 1896-97 amounted to 8,844 tons.

The sources of the rubber supply of the Amazonian region are approximately given by Mr. Consul Churchill as follows:—

Sources.	Quantity.
	Tons.
From River Purús.....	3,500
" " Madeira.....	2,200
" " Juruá.....	2,100
" " Solimões.....	1,000
" " Negro.....	700
" " Javary and Port of Iquitos..	1,500
From Peru and Bolivia (Caucho).....	2,000
" Para	9,000
Approximate annual production....	22,000

The internal water communication afforded by the River Amazon and its numerous branches is so great that railroads and other



FIG. 7.—CURING PARA RUBBER OVER THE SMOKE OF URICURI NUTS.



Fig 8.—IMPLEMENTS AND TOOLS USED IN CURING PARA RUBBER.

means of transport are hardly needed. Ocean steamers can reach Manaus, which is about 1,000 miles from the sea, at all times of the year. There is a regular service of ocean steamers plying during high river as far as Iquitos, a port of Peru, which is 2,200 miles from the mouth of the Amazons.

Mr. Churchill continues:—

"The great demand for rubber, and the ever-increasing prices for it, have the natural result of attracting the bulk of the people to this remunerative industry. So long as the demand for rubber continues, the prospects as regards the development of other agricultural industry will be comparatively insignificant."

It follows that the rich lands of the Amazon valley are practically untouched except to tap the wild rubber trees growing upon them. Nearly all the necessities of life are imported from other countries.

The town of Para or Belem, the head-quarters of the great rubber industry of the Amazon region, is on the right bank of the River Guama, and about 100 miles from the sea. It is not on the banks of the Amazon, but is connected with the latter by a labyrinth of narrow channels, through which passes all the shipping between the outer world and the numerous Amazonian ports inland. The true mouth of the Amazons is dangerous to navigation, and is avoided; hence the port of Para commands practically the whole Amazon region, and is the emporium where is transacted the largest india-rubber business in the world.

According to Mr. Churchill, during the year 1897, the distribution of Amazonian rubber from Para was as follows:—

	Tons.
United Kingdom	8,843
France	2,010
Italy	65
U.S. America.....	11,626
Total	22,544

The following Table (Fig. 9) indicates the price per pound of fine Para rubber during each year from 1887 to 1897 inclusive in London and Liverpool. This has been compiled from returns kindly furnished by Messrs. Hecht, Levis, and Kahn.

The highest prices of 1883 have not yet been reached, but since 1885, with some slight fluctuations, the price of fine Para rubber has been steadily rising. During the first three months of 1898 the average price was 3s. 9½d. Since then it has reached 4s. per pound.

A new form of Hevea rubber has lately appeared under the name of Mollendo rubber. This is shipped from the port of Mollendo on the Peruvian coast to which it is brought by rail from Lake Titicaca. Its original source is that portion of Bolivia which lies above the navigable portions of the River Beni. The price of Mollendo is nearly equal to that of Para. The quantity exported in 1894 was 85,000 lbs.

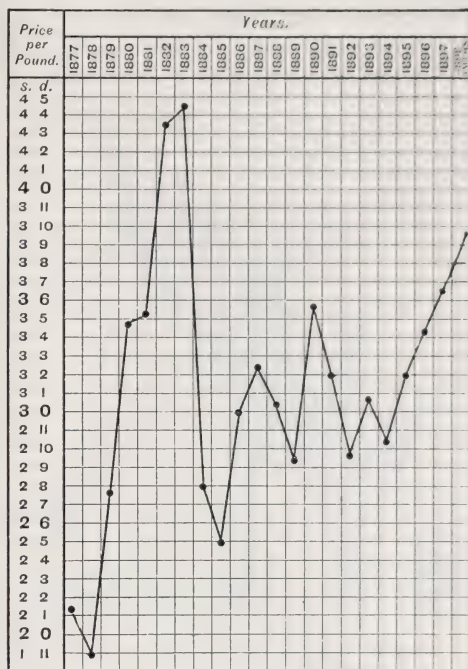


FIG. 9.

Bolivia is rich in Hevea trees. The total production in 1897 was about 850 tons, about 5 per cent. being Sernamby or negro-head rubber. According to Mr. Consul A. St. John there passed through the Bolivian Custom-house of Villa Bella on the Brazilian frontier, 69,040 arrobas of rubber in 1894. About 3,400 arrobas are said to have been exported through La Paz, whilst 3,000 to 4,000 arrobas were exported through Puerto Suarez on the Paraguayan frontier.

Mr. Churchill discusses the prospects of the Para rubber industry in Brazil as follows:—

"Some people suppose that the supply of Amazonian rubber may become exhausted in the near future. The most competent authorities are not all of this opinion, but maintain that the supply is inexhaustible, because the *Hevea* is continually being produced by nature. Certainly some areas become exhausted when overworked, but when left alone for

some time they recover. The district of Cametá, on the River Tocantins, gave an excellent quality of rubber. There was a special quotation for it in the foreign markets. This district, however, is now exhausted, because for about 40 years thousands of men have tapped its trees. All new-comers flocked to Cametá to make their fortunes. There are however, many districts that have not been tapped.

"The area that is known to produce Para rubber amounts to at least 1,000,000 square miles. Further exploration will no doubt show that this area is underestimated.

"The richest zones as at present known are along the banks of all the southern tributaries of the River Amazon, and on the islands in the main stream, and near Para.

"The most prolific part is on the River Aquiry, or Acré, one of the tributaries of the River Purús. Here 100 trees yield as much as one ton of rubber per annum.

"The northern tributaries of the Amazons do not produce much rubber. Of these, the River Negro produces the most. The quality, however, is soft. The River Branco produces very little rubber, and the upper part runs through pasture lands and high ground which is not suitable for good rubber. Some of the other northern tributaries have not been explored, and may yet reveal large stores of rubber. The *Hevea* is known to exist on the banks of the Japurá, but that district has not yet been opened up."

The great value of Para rubber trees has naturally suggested the desirability of introducing the cultivation into other countries. Seeds of *Hevea brasiliensis* were introduced to Kew in 1872, through Sir Clements Markham, K.C.B. (then Mr. Markham), and a first case of living plants was safely taken out to India by Dr. King, the Superintendent of the Botanical Gardens at Calcutta, in the following year. Since that time the Government of India has taken up the introduction of this valuable tree on a large scale. In 1875, Mr. H. A. Wickham was commissioned to collect seeds in Brazil, and he arrived at Kew with 70,000 seeds, of which only about 4 per cent. germinated. Upwards of 1,900 plants in 38 Wardian cases were, however, despatched from Kew to Ceylon (as the climate of Calcutta was found unsuitable to them), where they arrived in excellent condition. Small lots of plants were also distributed at the same time to the West Indies, the West Coast of Africa, Singapore, and Java. In 1876, Mr. Robert Cross, who had been sent to South America to bring home living plants in case the seeds brought by Mr. Wickham failed to germinate, arrived at Kew with 1,000 young plants. The greater number

of the survivors of these was also forwarded to Ceylon to be grown for distribution to India, and the rest to Mauritius, Singapore, and Queensland. Para rubber trees are now well established in various parts of India and in most of our Eastern possessions.

(To be continued.)

[Figures 6 and 7 are taken from the pages of *Commerce*.]

THE THERMO-CHEMISTRY OF THE BESSEMER PROCESS.

The following list of memoirs relating to the Bessemer process is supplementary to Professor Noel Hartley's Cantor lectures, printed in the last three numbers of the *Journal* :—

- "On Modifications of Bessemer Converters for Small Charges." By John Hardisty. Derby. "Journal of the Iron and Steel Institute," vol. ii., 1886.
- "Fabrication de l'Acier fondu par affinage de la fonte avec chauffage par combustions inter-moléculaires." A paper read by Professor Jordan before the French Society of Civil Engineers, May 20th, 1869.
- "Chemistry of the Bessemer Process." Lieutenant Dutton. *Engineering*, p. 200, 1870.
- "Generation of Heat during the Bessemer Process." Professor R. Åkermann. "Journal of the Iron and Steel Institute," ii., p. 110, 1872.
- Article "Steel." "Dictionary of Applied Chemistry," vol. ii., p. 872. Edited by C. W. Vincent. Published by Mackenzie, Glasgow. J. G. Snelus, F.R.S.
- "Applications of Thermal Chemistry to Metallurgical Reactions." A. Pourcel. "Journal of the Iron and Steel Institute," i., 1889, p. 152.
- "Thermo-chemical Study of the Refining of Iron." Professor Honoré de Ponthière. "Journal of the Iron and Steel Institute," ii., 1897.
- "Etudes Calorimétriques sur les carbures, les siliciures, et les borures de fer et de manganèse." "Annales de Chimie et de Physiques," 5th Series, vol. ix. 1876. By MM. Troost and Hautefeuille.
- "Manufacture of Iron and Steel." Sir J. Lowthian Bell, F.R.S. pp. 241.
- "On Some Early Forms of Bessemer Converters." Sir Henry Bessemer, F.R.S. "Journal of the Iron and Steel Institute," ii., 1886, p. 638.
- "Flame Spectra at High Temperatures." Part I. Oxyhydrogen Blow-pipe Spectra. Part II. The Spectrum of Metallic Manganese, of Alloys of Manganese, and of Compounds of that Element. Part III. The Spectroscopic Phenomena and Thermo-Chemistry of the Bessemer Process. W. N. Hartley, F.R.S. "Phil. Trans.," vol. 185, pp. 161, 1029, and 1041.

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CANTOR LECTURES.

SOURCES OF COMMERCIAL INDIA-
RUBBER.

BY DR. D. MORRIS, M.A., C.M.G.

Lecture I.—Delivered April 18, 1898

(Concluded from p. 760).

CENTRAL AMERICAN RUBBER.

It is generally recognised that the rubber known as Central American, including that exported from Mexico, Guatemala, Nicaragua, Panama, some parts of the U.S. Colombia, and the western slopes of the Andes as far as Peru, is produced by the Ule or Hule, the “olquaquilt” of the Aztecs (*Castilloa elastica*, Cerv.). This belongs to the natural order *Urticaceæ*, tribe *Artocarpeæ*. It is thus allied to the Bread fruit tree. Although the earliest described of all the rubber trees the species is not so well known as it should be, and according to Sir Joseph Hooker it is probable that more than one rubber-bearing species exists in Central America under this name. So far no *Castilloa* has been found to the east of the Andes, either in Brazil or Venezuela. The tree has a very extensive geographical range and is evidently capable of existing under considerably varied climatic conditions.

Castilloa elastica, Cerv., when fully grown, is of an imposing height; specimens have been met with 160 to 180 feet high, with a stem 12 to 15 feet in circumference. It grows very rapidly. The bark is rather soft and smooth and the young branchlets are densely covered with reddish brown hairs. The leaves are usually very large, 12-18 in. by 4-7 in., with a cordate base; the margins are studded with minute tufts of hairs while the under side is densely clothed with tawny hairs. The flowers are male and female on the same branch embedded in a top-shaped

receptacle clothed outwardly with closely-packed scales. The fruits are about 2 in. diam. containing numerous seeds immersed in a fleshy receptacle. The latter are $\frac{1}{4}$ - $\frac{1}{2}$ in. diam. with a white papery seed-coat.



FIG. 10.—THE ULE TREE (*Castilloa elastica*, Cervantes).

Yielding Central American rubber, one mature leaf and a terminal leaf-shoot—one-third natural size. (1) Group of female flowers or pistillate receptacle; (2) a single female flower with exerted filiform stigmas, usually two, but rarely three; (3 and 4) sections of ditto, showing the ovary in different stages of development; (5) magnified portion of margin of leaf showing stiff bunches of hair.

The following particulars are furnished by Sir Henry Dering respecting the distribution of *Castilloa elastica* in Mexico (F.O. Report, 1895, p. 21):—

“The rubber tree (*Castilloa elastica* of Cervantes, *olquaquilt* of the Aztecs, *hule* of the Spaniards) is indigenous to Mexico, and is found growing wild along both coasts, below 22 degrees north latitude, from sea-level to altitudes running from 1,200 to 1,500 feet, and principally by the river banks. The region most favourable for the growth of this important yet rarely cultivated tree are the plains of Pochutla, Oaxaca, between the Pacific Ocean and the base of the Sierra Madre Cordillera, and also along the banks of the Copalita river; in Soconusco, Chiapas, below the coffee belt, and in Pichucalco and Mezcalapa, along the great Grijalva river clear down

to Tobasco; in the Papaloapan and Tuxtepec valleys clear up to the Rivers Tonto and Quiotepec, and the lands on the Gulf side of the isthmus, covering an extension of 1,100 square miles, where the tree is found in astonishing numbers throughout the forests that skirt the Coatzacoalcos, Uspanapa, Coachapa, Chalhijapa, Del Corte, Chichihua, Malatengo, Sarabia, Jumuapa, Jaltepec, San Juan, Trinidad, and Colorado rivers."

In British Honduras, the Ule is found on what are known as the Cohune ridges, and especially along the banks and in the valleys bordering Mullin's river, Sittee river, and the Rio Grande in the south; and along the Sibun river and the upper waters of the Belize river in the west. It is still abundant in some localities, but is becoming scarce in the neighbourhood of settlements. In Guatemala and Nicaragua, the trees are only now found in the interior valleys—their number is rapidly diminishing everywhere. In the U.S. Colombia in Panama and Darien, the trees are said to exist in great numbers. Along the valley of the Magdalena river (100 miles from its mouth, and extending for a distance of 600 miles, and a width varying from 20 to 60 miles) the rubber tree is said to abound and to reach for 1,000 feet up the sides of the mountains. The soil over so extensive an area naturally varies a good deal. It is, however, recognised that the plant avoids marshy and boggy land, appearing to prefer warm, deep loam or sandy clay, and especially affecting the margins of small running streams, where it grows in little groups. A dry or a rainy climate seems equally suitable, but a high and equable temperature, which does not fall below 60° F. at any time, is essential.

The *Castilloa* tree has been met with near Guayaquil towards Chimborazo by Spruce, and doubtfully on the slopes of the Bolivian Andes.

In the winter of 1882, I visited British Honduras for the purpose of preparing a report on the resources of the colony. I carefully studied the native rubber trees, and from the observations, soon after published, I select the following extracts*:

"The *Castilloa* rubber-tree is fit to be tapped for caoutchouc when about seven to ten years old. The milk is obtained at present from trees growing wild, by rubber-gatherers, who are well acquainted with all the localities inhabited by the Ule. The proper season for tapping the trees is after the autumn rains, which occur some months after the trees have

ripened their fruit and before they put forth buds for the next season. The flow of milk is most copious during the months of October, November, December, and January. The rubber-gatherers commence operations on an untapped tree by reaching with a ladder or by means of lianes, or 'tie-ties,' the upper portions of its trunk, and scoring the bark the whole length with deep cuts, which extend all round. The cuts are sometimes made to form a series of spirals all round the tree; at other times they are shaped simply like the letter V, with a small piece of hoop-iron, the blade of a cutlass, or the leaf of a palm placed at the lower angle to form a spout, to lead the milk into a receptacle below. A number of trees are treated in this manner and left to bleed for several hours. At the close of the day the rubber-gatherer collects all the milk, washes it by means of water, and leaves it standing till the next morning. He now procures a quantity of the stem of the moon-plant (*Calonictyon speciosum*), pounds it into a mass, and throws it into a bucket of water. After this decoction has been strained it is added to the rubber milk, in the proportion of one pint to a gallon, or until, after brisk stirring, the whole of the milk is coagulated. The masses of rubber floating on the surface are now gathered from the liquid, kneaded into cakes, and placed under heavy weights to get rid of all water particles. When perfectly drained and dry the rubber cakes are fit for the market and are exported generally in casks. In Spanish Honduras and other places in Central America, instead of the juice of the moon-plant a solution of alum is used to coagulate the milk; but it is said that the injudicious use of alum tends to make the rubber hard and brittle, and to depreciate its value."

"*Yield*.—A large tree of *Castilloa*, say two feet in diameter, is said to yield eight gallons of milk when first cut. Each gallon of milk in the proper season will make about two pounds of rubber. Hence a tree of this size will give a return of sixteen pounds of rubber. The gatherers are supposed to require a license before they can tap trees on Government lands; but practically there are no restrictions placed upon them, and trees of all ages and sizes are ruthlessly bled, many of which I fear never recover."

I have recommended the adoption of this Central American rubber as a good tree for all tropical plants requiring shade, and also as the rubber tree which offers the most favourable inducements to the planter to undertake its cultivation. The *Castilloa* tree grows in deep loamy or sandy soil, is a deep feeder striking its roots far into the ground, and not exhausting the surface soil; again, it grows with wonderful rapidity, soon forming a large handsome shade-tree; and lastly, it gives a return in rubber within eight or ten years, while some other trees do not mature for twenty or thirty years. In a cacao plantation the rubber trees

* "The Colony of British Honduras." By D. Morris. London: Edward Stanford. 1883. pp. 74-81.

may be planted at 40 feet apart, or one tree between every three of cacao. When young the lower branches fall off naturally, and by a little subsequent trimming and pruning the trees might be so trained as to give the requisite shelter and shade, while at the same time there is a clean stem for facilitating the

In Mexico the milk is collected in earthen vessels (jacaras) and afterwards boiled to produce coagulation. In Costa Rica the milk is allowed to flow into a large hole in the ground, and forms into a cake, known as a "torta." Good rubber of a scrappy character is obtained from the channels, or cuts in the



FIG. II.—ULE TREE (*Castilloa elastica*, Cervantes).

Yielding Central American rubber, a tree about ten years old, growing in British Honduras (from a photograph taken by Mr. E. D. M. Hooper, of the Indian Forest Department). The spiral cuts on the stem illustrate the manner in which the trees are tapped. On the extreme left may be noticed the vertical gutter connecting the transverse cuts and conveying the milk to the base of the tree. The tree represented is growing on the edge of the forest in a clearing amongst bananas, coffee, and other tropical plants.

extraction of the rubber. If rubber trees are planted in cultivated areas, as shade-trees for cacao, Liberian coffee, oranges, &c., as mentioned above, the return from them at the end of eight or ten years would average at least about £1 sterling per tree, or at the rate of £25 per acre.

trees; this is known as "borricha." Similar methods are adopted in Ecuador. In the U.S. of Colombia various methods are adopted; at Panama, coagulation is effected by the use of soap, wood ashes, alum, or the leaves of the *Caloniclyon*. A white rubber at Colon is prepared by simple exposure to the sun. In the

Magdalena valley the rubber is dried in the sun or by gentle heat.

According to Mr. Consul Kerbey—

"The method of gathering and preparing the caoutchouc of Peru is to fell the tree and cut it up into bits, limbs and all, and let the milk run out from the wood into hollows dug in the ground. It is then coagulated in these pools by mixing it with ordinary soap. It produces a most vile-smelling compound, which sells for about the same price as Para sernamby."

The United States Consul-General at Panama states:—

"The india-rubber of this district is obtained entirely from the tree known under the general name of 'caucho.' This produces the darker variety of Panama rubber, and supplies the chief part of the total product. Besides the ordinary caucho there is the 'caucho-forube,' which gives a light-coloured article known as 'virgin-rubber.' A third variety is called 'caucho-macho,' or male-rubber, because it gives very little milk, and that useless, as it will not coagulate."

Central American rubber appears in commerce in various forms. That from Nicaragua comes in "sheets" and "scraps." The former are in pieces $2\frac{1}{2}$ feet long, weighing from 10 to 40 pounds. "Scraps" are formed of the shreds and pieces collected from the cuts on the trees. The latter are drier than the sheets, and there is little loss in shrinkage. "Carthagena strip" is a black, tough rubber. Guayaquil rubber is in large flakes and lumps of a whitish colour in the best sorts. The inferior sorts are porous, exuding a black liquid. The mechanical treatment of the latex of *Castilloa* trees suggested by Mr. Biffen is likely to greatly improve the quality of the rubber.

A plant known in British Honduras and some of the republics to the south under the name of "Toonu" or "Tunu" is apparently an undescribed species of *Castilloa*. It yields a spurious kind of gutta-percha, but so far little has been done with it commercially. It is probable that some of the milk of the "Tunu" is mixed by the collectors with that of the *Castilloa elastica*, and this may account for the difference in quality of some shipments of rubber from Central American ports.

Mr. Consul Mallet, of Panama, in his report for 1897, states:—

"Several as yet unproductive plantations of india-rubber trees exist on the isthmus, which, when mature and capable of being tapped, are expected to yield good paying results as much on account of the attention bestowed upon them as on the better class of

rubber, which can be obtained under such conditions with greater care and in a cleaner manner than in the depth of the forest."

In all Central American countries, the Consuls report that the rubber trees are being rapidly exterminated and the exports are steadily diminishing. Consul Leay (Panama) states:—"Rubber has appreciably dwindled owing to the working out and destruction of the trees in near forests, the cost of production increasing with the increased distance." Consul MacLachan (Spanish Honduras) reports:—"The export of rubber is small and decreasing yearly mainly owing to the carelessness of the Government in permitting rubber collectors to cut the trees down instead of tapping them." Consul Bingham (Nicaragua) states:—"Business in Greytown formerly depended, to a considerable extent, on the extraction and exportation of india-rubber, but the india-rubber trees in this neighbourhood have been almost entirely destroyed by excessive bleeding, and the commerce of Greytown is now chiefly confined to the carrying and merchandise trades with the interior of the Republic and the Mosquito Coast." Consul Hayes Sadler (Guatemala) reports:—"In spite of endeavours to protect the trees, the production of rubber decreases, and only in Vera Paz and Peten are trees found in any quantity, while agriculturists show no sign of replacing those that are worn out." Similarly in Mexico, "the supply of india-rubber in accessible regions is considerably diminishing, while the demand for it is steadily on the increase."

The largest share of Central America rubber is shipped to the United States. In 1887 to 1888, the United States received rubber of the value of \$153,004 from Mexico, out of a total export value of \$162,385 (Mexican currency). The total imports into the United Kingdom during the year 1897 were 5,000 cwts. of the value of £70,000.

Through the enterprise of the Government of India, the *Castilloa* trees of Central America have been successfully introduced into the East Indies, and also to most British possessions in other parts of the world. An interesting account of the steps taken in this direction was contributed by Mr. Thiselton Dyer, C.M.G., F.R.S., in a paper by Sir Joseph Hooker, G.C.S.I., in the "Transactions of the Linnean Society" (Botany), vol. ii., pp. 212-214. The following embraces the chief facts:—

In the summer of 1875 the India-office des-

patched Mr. R. Cross to Darien to obtain seeds and plants of *Castilloa elastica*. Unfortunately Mr. Cross's expectations as regards the seeds were realised. The whole parcel failed to germinate. Mr. Cross, however, with considerable difficulty, and after undergoing shipwreck, succeeded in bringing safely to Kew a considerable collection of cuttings, from which a supply of plants was raised. Of these, two plants were despatched to Dr. Thwaites, Director of the Royal Botanic Gardens, Peradeniya, Ceylon, April 27, 1876, and 31 on August 9 following. Of these last, 28 arrived alive.

A further consignment of 24 plants was sent in 1877 to Dr. Thwaites, who meanwhile had been establishing the former consignment in the tropical garden at Henaratgode. Here they made satisfactory progress, Dr. Morris describing them, May 18, 1878, as growing "into broad wide-spreading trees with a very majestic air."

In 1880 Dr. Trimen, who had succeeded Dr. Thwaites, reported:—"Much better success now attends the propagation by cuttings of this fine species. Our largest trees at Henaratgode have now a circumference of nearly 17 inches at a yard from the ground, and the trees are beginning to take their true form."

In the following year Dr. Trimen reported:—"The *Castilloa*, both at Peradeniya and Henaratgode, produced flowers during the dry weather of April; on examination, however, these were all male. This species is said not to produce seed till eight years old. The finest tree at Henaratgode has now a stem of 22½ inches in circumference at about a yard from the ground."

In October, 1882, Dr. Trimen forwarded to Kew a sample of the rubber of *Castilloa elastica* grown in the experimental gardens at Henaratgode, Ceylon. The original plant was sent from Kew in 1876. The sample was submitted to S. W. Silver, Esq., F.L.S., who very kindly reported upon it:—

"On working and drying a portion of this sample the loss is 12·3 per cent.; it is necessary to use warm water in washing this rubber; it becomes on drying much darker and shorter than Para rubber. It has a bitter taste which is not removed on washing. The unwashed sample yields 1·9 per cent. ash, the washed sample gives 1·2 per cent. The shortness of this rubber would restrict its use to some extent where tensile strength or tenacity is required. It was valued, December 8th, 1882, as worth 2s. 9d. to 3s. per pound."

The plants distributed from Kew and now under cultivation in various tropical colonies

would be more correctly termed, according to their place of origin Darien *Castilloa* or Darien Caucho trees. This would distinguish them from the Ule trees of Mexico, British Honduras, and Nicaragua, and indicate their history. It is possible that there is no great difference, if any, in the quality of the rubber yielded by these trees, but so far no one has undertaken a comparative investigation of the produce.

Castilloa trees have not yet been established on a large scale in any part of the East Indies. They have been very successful in Trinidad, and are regarded there as the most promising rubber trees introduced into the island. There are trees in the Botanic Gardens sixty feet in height, yielding annually large supplies of seed. In 1896 Mr. Hart reported:—"We have raised and sold some 10,000 *Castilloa* this year, and we have a plantation in Tobago and one here ready for tapping."

At the St. Lucia Botanic Station there is a tree 50 feet high and 14 inches diameter at the base. This and other trees in the island yield regular supplies of seed. Several hundred plants are annually distributed. At St. Vincent *Castilloa* trees are seedling, and 100 plants are ready for distribution at the botanic station. Five trees are seeding at the botanic station at Dominica, although under eight years old.

CEARA RUBBER.

The plant yielding what is known in commerce as Ceara rubber or Maniçoba is *Manihot Glaziovii*, and is named after Dr. Glaziov, who first contributed specimens of this species to the Kew Herbarium. It is an Euphorbiaceous plant. A description is given in Martius' *Flora Brasiliensis*, xi. p. 443, and a full account, with a plate, in the "Journal of Botany," 1880, pp. 321-325. It is a moderate-sized tree, 30 to 50 feet high, with a stem about 8 to 20 inches in diameter, with numerous wide-spreading branches. The bark is purple grey, the thin silvery outer layers readily peeling off in narrow strips. The leaves are deeply lobed, thin in texture, and of a bluish-green colour. The flowers are rather large, with the male and female separate on the same raceme. The fruit is a large drooping capsule containing three polished seeds, greyish yellow mottled with purplish black. In the young condition the Ceara rubber plant somewhat resembles the well-known Cassava or Mandioca plant, and it has similar swollen roots.

The country where the tree is found in North-east Brazil, is described by Mr. Cross

in his report to the India-office in 1877, as possessing a very dry arid climate for a considerable part of the year. "This is evident" he states "from the fact that mandioca and other crops require to be irrigated. The rainy season is said to begin in November, and end in May or June. Torrents of rain are then reported to fall for several days in succession, after which the weather moderates for a brief space. According to some statements, there are occasional years in which hardly any rain falls. This assertion concurs with the aspect presented by the country in general. The daily temperature on board the ship ranged from 82° to 85° F., but inland it is often probably 90°. The localities traversed by me nowhere seemed to be elevated more than 200 feet above the sea." At Pacatuba, about forty miles from Ceara (the actual place where the specimens were obtained), "the general forest was tolerably high, but the sparse, small foliage did not afford much shade from the fierce rays of the sun. The soil was in places a sort of soft sandstone or gravel, which was bound up in the most extraordinary manner. Neither grass nor weeds grew among this underwood, and there was an entire absence of ferns, mosses, and other plants." In another place, somewhat further from the coast, the traveller, shortly after entering the bush-like forest, "came on a large tract of land covered by immense masses of grey granite, some of which might be fifty tons or more in weight. Rounded masses of the same rock also cropped out in many places. . . . Many good-sized rubber trees were growing in the spaces between these granite masses. . . . The situation was very dry, but no doubt some seedlings had sprung up, which, owing to numerous thickets of shrubs, were not perceived."

The Ceara rubber plant was first brought into prominence in 1876, when Mr. Cross, employed by the India-office, brought to Kew seeds and plants, from which, during the next and following years, consignments of plants were distributed to India and Ceylon, and all parts of our Eastern and Western possessions. At the end of 1877, supplies of seed were produced in Ceylon. From that time, the distribution of the plant was assured in all tropical countries.

Of Ceara rubber there are imported into this country about 200 to 300 tons per annum. There are three grades found in commerce, varying according to the mode of tapping the trees and the care taken in the preparation.

When pure it is regarded as almost next to Para in value. It is a "dry" rubber, very elastic and free from stickiness. It is, however, often mixed with wood and foreign matter, causing a loss to the manufacturer amounting sometimes to 25 per cent. It would appear that the Ceara rubber industry is not extending in South America, for "every year there is an extensive migration of Ceara people to Para bound for the forests of the Amazon." In case 96 in Museum No. 1 at Kew, are found samples from Brazil, and also from plants grown in India, Ceylon, Natal, and Zanzibar. It may be mentioned that the rubber produced under cultivation in Ceylon has been singularly pure and free from impurities. In 1883, according to Dr. Trimen, "as much as 4s. per pound had been obtained for Ceylon Ceara rubber."

System of collecting the rubber.—According to Cross, "this is an operation of a very simple description. On commencing to work, the collector takes with him a stout knife and a handful of twigs to serve as a broom. Arriving at a tree, any loose stones or dust are swept from the ground around the base, and some large leaves are laid down to receive the droppings of milk which trickle down. Some do not go to the trouble of sweeping the ground or laying down leaves, for which reason the milk adheres to sand, dust, decayed leaves, and other impurities. The outer surface of the bark of the trunk is pared or sliced off to a height of four or five feet. The milk then exudes and runs down in many tortuous courses, some of it ultimately falling on the ground. After several days the juice becomes dry and solid, and is then pulled off in strings and rolled up in balls, or put into bags in loose masses. Only a thin paring should be taken off, just deep enough to reach the milk vessels; but this is not always attended to. Nearly every tree has been cut through the bark, and a slice taken off the wood. Decay then proceeds rapidly, and many of the trunks are hollow. In this condition the trees must yield far less milk, and many no doubt are broken over by the wind, or wither away. Collecting is carried on during the dry season only, when rain seldom falls."

Germination of Seed.—In "Notes on some Trees yielding India-rubber," by the late Dr. Trimen, he states:—"The seed-coat is of remarkable thickness, and very hard, and the natural process of germination occupies a long period—it is said more than a year. All that is necessary to hasten this, if desired, is to assist the seed coat in splitting. This is best effected

by holding the seed firmly, and rasping off with a file both edges at the radicular end. It is best not to file off the actual end, as it may thus easily happen that the radicle of the embryo may be injured. After this treatment, properly performed, the young plant appears above ground in two or three weeks. The seedlings require no particular attention. They grow rapidly and may finally be planted out at distances of 20 feet. A peculiarity which they share with their close relative the mandioc is the possession of large tubers on the spreading roots. The trees at Peradeniya, from which seed has been distributed to Burma, India, Jamaica, &c., flowered at the age of 18 months, and at the present time ($2\frac{1}{2}$ years) the larger ones form branching trees about 25 or 30 feet high, with a stem 1 ft. 9 ins. in circumference at a yard from the base, and a smooth, silvery birch-like bark readily peeling off; being about half the size of those which Mr. Cross describes, and which may be assumed to have been fully grown."

Propagating and Planting.—Mr. Cross suggests "the formation of plantations by cuttings, which will take root as easily as a willow. These should be taken from the points of strong shoots and may be one foot in length. In planting, each cutting may be put down in the soil to a depth of six inches. If scarce, the entire shoot may be cut into pieces, each possessing a bud, all of which will grow if covered with half an inch or so of soil. On loose sandy soils or exhausted coffee land, plantations may be formed at little expense. Hard dry gravelly wastes, if found to support any kind of bush, are also suitable sites. Holes might be made in strong land with an iron jumper and a stout cutting put into each and filled with pebbles. On bare or thinly covered portions of rock the cuttings might be laid down flat, and a little heap of stones or any kind of *débris*, about the size of a molehill, piled over each, care being taken that the extreme point of each cutting with a bud is left uncovered. I do not advocate planting in an entirely barren desert, but wherever there is any sort of stunted tree or scrub vegetation, with an occasional sprinkling from a monsoon shower, the tree is likely to prosper."

Dr. Trimén adds:—"Experience of the plant in the botanic garden has proved the general accuracy of the above remarks. There can be no doubt of the hardiness of the species, its readiness of culture, and adaptability to circumstances. It grows equally readily from seed or from cuttings, and, though a native of

a tropical sea-level, thrives well here in Ceylon up to at least a level of 3,000 feet and on the most barren soils. It has succeeded equally in Calcutta and Madras, but the wet season seems to have killed it at Singapore. It would seem especially adapted for the dry and barren districts of our eastern and northern provinces, or in the higher districts, but it would not be wise to risk it in localities where the temperature is liable to fall below 60° F." (Fig. 12, p. 768.)

The cultivation of the Ceara rubber tree was carried on with considerable energy in Ceylon for many years. Numerous experiments were made to find out the best means for tapping the trees and producing the rubber in commercial quantities.

The following note by Dr. Trimén, published in his report for the year 1883, gives an excellent summary of the results up to that year:—

"A planted area of 977 acres is credited to this cultivation, but rubber has not yet appeared among our exports. Since it has been ascertained that the quality is excellent, cultivators have been endeavouring to discover a means by which the milk can be obtained at a cost sufficiently low to give a return, but without, as yet, encouraging results. The removal of the outer separable bark has been objected to on the ground that the bark formed in its stead is of a different character, very hard and inseparable from the green layer a second time. Instruments have therefore been devised for bleeding without such removal. A knife with two parallel blades, which took out a strip of bark, has been modified into one in which the very sharp cutting edges meet to form a V, the basal angle during use being at the cambium. Another invention avoids all cutting, being a double spur-like wheel with sharp but guarded points, which puncture the bark without further injury. The milking (one can scarcely call it tapping) has also been practised on trees of various ages and at different intervals and seasons. While it is found that the yield of individual trees varies extremely, none of the experimentors are satisfied that the small quantity obtainable by present methods is sufficient to make the cultivation profitable at the existing price of rubber. Mr. Wall, however, who states that hundreds of young trees have been bled daily with the 'pricker' for some weeks, and that thus a coolie can collect about half a pound of dry rubber per diem, thinks that, if trees will bear this treatment for 240 days in the year, the cultivation would be remunerative. It appears evident that milking must be repeated at frequent intervals, and (as often already pointed out) the cultivation be conducted on a large scale. Much of the 35,000 acres in private hands in Ceylon, at present growing nothing but *Lantana* and other weeds, is suitable for this hardy plant, which costs nothing to cultivate, affords a substance of a value which is continually increasing,

and awaits only the discovery of a process by which the latter can be cheaply and exhaustively extracted."

Dr. Trimen's final views are given in his report for the year 1890:—

"Interest in Ceara rubber has of late years very much died away, the yield of rubber having been found too small to satisfy the planter's expectations. Thus I have made no report on it since 1884. There are, however, considerable plantations on some estates, and now that the trees are older it is found to be profitable to harvest the product. Several shipments

to dry on the tree, and are picked off, the resulting product being quite like 'Ceara scrap' of commerce, but in small tears. The present opinion of planters seems to be that this kind of rubber pays to harvest, but not to cultivate, and they are prepared to destroy their trees to get the crop. But even on such a system (which has largely been followed here with cinchona) extensive areas of bad soil could surely be profitably occupied with this tree, so grown as to provide a crop annually ready for tapping."

In Madras, at Chatrapur, Ceara rubber trees



FIG 12.—TREE YIELDING CEARA OR MANIÇOBA RUBBER (*Manihot Glaziovii*, Muell. Arg.).

Growing on Mahadoya Estate, Lunugala, Ceylon. From a photograph in the Kew Museum, presented in 1883, by Mr. A. T. Karslake. This tree is about six years old. The low bushes in the foreground are Liberian coffee.

have been made to London during the past year, and have realised very good prices. Of course the quantities have not been large. One shipment of 4 cwt. fetched 1s. 8½d. to 1s. 9½d. per lb. net, showing a profit here of about 37 cents (of a rupee) per lb. A planter estimates the cost of collection at about 36 cents per lb., and reckons that trees of eight years old afford at least 3 ozs., whilst some ten years old gave half a pound. The collection is done in a somewhat primitive way during the dry season, January to March. After the outer flaky layers of bark have been peeled off, the inner bark is pricked copiously; the tears of rubber which exude are allowed

have done well. Samples of the rubber have been valued (in 1896) at 1s. 6d. to 2s. per pound. The plants have not done well in other parts of India, and they have, apparently, failed in the Straits Settlements, Zanzibar, and West Africa. In the West Indies there has been no difficulty in growing the trees; they are reported to have done remarkably well in Jamaica and Dominica, but no rubber has been obtained from them. It is possible that with renewed attention to the trees more definite results may follow.

The following recent information respecting Ceara rubber is taken from the *Kew Bulletin*, for January-February, 1898, pp. 13-15. This was obtained as the result of a visit made to the north-east coast of Brazil by Mr. Esme Howard, and Mr. R. H. Biffen, Demonstrator in Botany at the University of Cambridge, during 1897. The occurrence of the plant at an elevation of 3,600 feet, and the wide range of conditions under which it appears to thrive, are facts that have not hitherto been fully recognised. It is quite possible that we may yet see successful plantations of Ceara rubber trees established in districts that have been regarded as unsuitable, and under conditions that may afford a sufficient yield of rubber to render the enterprise remunerative. Mr. Biffen has furnished the following particulars as the result of personal observations on trees in the wild state :—

“The leaves fall in August and September. Seeds produced very abundantly; ripe in September; they keep their power of germination well. The tree is apparently very liable to a dry-rot, for rotten branches are continually falling. Growth is very rapid; in Baturité we saw one-year old plants 10 to 12 feet high; in five to six years it is ready to tap; then it is some 25 feet high and 8 to 9 inches in diameter. Propagated either from cuttings or from seeds. So far nurseries have failed in Ceara. Shade for established trees is unnecessary. Large plantations are now being made in the district.

“The tree has a singularly wide range of conditions; it grows in the desert plains where rainfall is said to be under 50 inches, and the vegetation is scorched up for the greater part of the year; also, in the mountains (plantation at 3,500 feet at Monte Alegre) where rainfall, I should say roughly, is over 100 inches. In the mountains the temperature falls even below 60° F. at night. The tree is never found in marshy soil; apparently it thrives best in somewhat scanty soil among granite boulders.

“The rubber is exported in three forms :—(a.) In pale yellow-brown threads, $\frac{1}{4}$ inch in diameter, and several inches in length, obtained by peeling off the thin layer of old bark, and making a slight incision with a narrow-bladed axe. A small quantity of latex flows and coagulates on the trunk. (b.) In small flat cakes, prepared by tapping the base of the tree, and allowing the latex to flow on the ground and coagulate there. Hence, the rubber contains large quantities of dirt on its lower surface, which is removed to a certain extent by rubbing in coarse-meshed sieves. (c.) By smoking with the vapour from the burning nuts of a palm, in a similar manner to Para rubber. So prepared, it contains a large quantity of water, which partially sweats out on exposure to the heat of the sun. The exudation on

evaporation leaves a brown resinous substance. This last method is becoming very general.

“To collect the latex small tin cups are used; each tree is tapped 80 days, divided, by an interval of about three months, into two periods of forty each. Under this system the tree is said to live for 15 to 20 years. The tapping is always done in the dry season—from July to December. The average yield per tree is from $\frac{1}{2}$ to 1½ kilos. (1 to 3 lbs.) per year; coagulation may be effected by churning, or by the addition of an excess of water, or salt solution. In the former case the rubber particles which are unprotected by any film (as the fat particles of milk are) simply adhere to form a mass.

“In the case of the addition of excess of water, salt, or smoking, coagulation is brought about by means of the globulin present (Green, ‘Proc. Roy. Soc.’ 1886, p. 39), this coagulates at 74–76° C., or on dilution, &c., and tangles up the rubber particles in its meshes, much as white of egg gathers up particles in suspension when used for clearing jellies.”

The result of experience so far gained in the experimental cultivation of the Ceara rubber plant is summarised in the *Bulletin* as follows :—

“1. The plant is readily propagated both from seeds and cuttings. Seeds are abundantly produced in almost every part of the world where the plant has been introduced. They may be gathered from plants when only three to five years old. There is therefore the great advantage that a large area could be planted within a comparatively short period. Sowing the seeds in the position where they are to grow permanently is universally adopted in Brazil. It is possible, if adopted elsewhere, this plan would greatly reduce the cost of establishing plantations.

“2. The Ceara rubber plant is very hardy, a fast grower, free from insect and fungoid attacks, requires little or no attention when once established, and thrives in poor, dry, and rocky soils unsuited to almost any other crop. It is evident, however, that the yield of a few trees cannot be remunerative, and only large areas can hope to make the industry a paying one.

“3. It produces a good class of rubber, second only, when well prepared, to the best Para rubber. For this, there is a steady and continuous demand. The yield per tree is apparently small, but a return is obtained earlier than from any other rubber plant. With thick planting and judicious thinning as the trees grow up, it may be possible to increase the yield hitherto recorded; while with skilful treatment the permanent trees may be tapped

twice yearly, and last in a productive state for 15 to 20 years.

"4. In spite, therefore, of the apparent want of success which so far has attended experiments with Ceara rubber plants in Ceylon and other countries, the increasing importance of rubber as an article in large demand in all civilised countries at good prices, suggests a reconsideration of the merits of this interesting plant. In many of our colonies possessing a dry climate and a poor stony soil, it is possible that large areas could be profitably occupied with Ceara rubber trees so grown as to provide annual crops for tapping."

Commenting on the above the *Ceylon Observer*, a high authority on tropical subjects, states, "we feel very strongly that more might be done in Ceylon with Ceara rubber and that cultivation was not persevered with, ten years ago, because of the 'boom' in tea. But now in dry districts not suitable for Para the Ceara kind might well be planted."

MANGABEIRA RUBBER.

The tree yielding this rubber is known in Brazil as Mangaba or Mangabeira. It is *Hancornia speciosa*, Gom., belonging to the Dogbanes (*Apocynaceæ*). It is usually small and slender, somewhat resembling the weeping birch in habit, with drooping branches and small oblong leaves, sharp at the base and rounded but with a short point at the apex. It bears a delicious fruit, which is a great favourite with the Brazilians, but it is only fit to eat when perfectly ripe and after being kept for a short time. It is about the size of a plum, of a yellow colour marked with red spots or streaks.

The Mangabeira is found nearly all over Brazil. It flourishes on loose sandy soils unsuitable for almost any other crop. Its northern limit is on the Rio Negro. It extends to the Peruvian frontier on the west; on the east it is found in the States of Pernambuco, Bahia, Goyaz, Minas Geraes, Rio Janeiro, and Sao Paulo; it is found also in Central Brazil in the southern portions of the State of Matto Grosso. What may be a similar, or probably the same, species was collected by Balansa at Jacuati, south-east of Concepcion in Paraguay. In any case, it produces caoutchouc.

One of the earliest notices of the *Hancornia* as a source of india-rubber appears in the Report of the British Association, 1855, p. 103, by the Chevalier de Claussen. He stated:—

"In the course of my travels as botanist in South America, I had occasion to examine the different

trees which produce india-rubber, and of which *Hancornia speciosa* is one. It grows on the high plateaux of South America, between the tenth and twentieth degrees of latitude south, at a height from 3,000 to 5,000 feet above the level of the sea. It bears a fruit in form not unlike a bergamot pear, and full of a milky juice, which is liquid india-rubber. To be eatable, this fruit must be kept two or three weeks after being gathered. It is regarded by the Brazilians (who call it Mangava) as superior to all other fruits of their country. A beverage is also made from it, and also conserves or 'doces.' I have tried to mix the rubber with resinous or oily substances, in combination with tannin, and have succeeded in making compounds which can be mixed in all proportions with gutta-percha or india-rubber without altering their characters."

The following is taken from the "Kew Report" for 1880, p. 47:—" *Hancornia speciosa*.—Our attention being drawn to this plant as the source of Mangabeira rubber, steps were taken to obtain through correspondents a supply of seeds. These we have received, and the plants raised from them will, in due course, be distributed."

Consul Bonham, in 1879, reported:—

"Mangabeira rubber is obtained from the trees of that name, which are to be found in large numbers in the interior of Pernambuco, as well as of the other northern provinces. The reports which I hear have been received from Liverpool of the reception of this article are far from favourable; the price went up to 2s. 7d. per lb., but has fallen again, and it would appear that 1s. per lb. is about the price obtainable in England in ordinary times. The method employed in the preparation of the rubber is very primitive, and, I think, may easily account for the article not being well received. If the milk were treated in a more careful manner, there seems no reason why the rubber should not be favourably received. At present the plan adopted is simply to mix alum with the milk, which causes it to coagulate; the lumps of rubber are then placed in the sun, after which they are sent to the market. From this defective mode of preparation a great loss of weight afterwards occurs, frequently as much as 40 to 50 per cent., some say even more."

The *Kew Bulletin*, 1892, p. 69, quotes the following particulars:—

"From Bahia and Pernambuco, in Brazil, comes a rubber of a different grade from that of Para. It is cured with alum and water. The Pernambuco comes in sheets, and is of a yellowish white tint; that from Bahia is not so good, and comes in round balls. The principal objection to it is that it is very damp, entailing a large loss to the importer from shrinkage.

"Of Mangabeira rubber there are three grades, very similar to the Bahia and Pernambuco sorts. A grade that has a red look is considered superior, and sells for five or ten cents per pound higher than the others."

An account of the mode of tapping *Hancornia* trees and preparing the rubber in Pernambuco was given in the *Journal of the Society of Arts*, 1880, p. 634. The tapping is done by incisions as in the case of Para rubber trees, or by a long spiral cut. The milk runs rapidly at first then very slowly; it is of a pale pink colour due to a colouring matter in the young bark. The latex is coagulated by the use of alum. According to Mr. Biffen it is also "clotted" by adding an excess of common salt. The latter treatment causes the rubber to be full of cavities and wet or spongy. The more advantageous method would be to treat it by centrifugalising, as already described.

Fuller details of the Mangabeira rubber industry are contained in the Special Consular reports on india-rubber, issued by the United States Government in 1892, pp. 394-397. The largest production of Mangabeira rubber takes place in the States of Minas Geraes, and Goyaz, whence one-half is shipped to Rio de Janeiro and the other half to Bahia. That to Bahia is brought some distance down the river San Francisco, then by mules, and lastly by rail, until it arrives at Bahia. The export of crude rubber in 1889 was about 134 tons. There is an export duty of 14 per cent. No experiments appear to have been made in cultivating the tree. The exports from Pernambuco, in 1896, were 54 tons, of the value of £1,800; from Bahia, in 1892, they were 4,362 packages of the value of £22,826, and in 1893 3,293 packages of the value of £20,362.

A small quantity of india-rubber from the State of Matto Grosso (probably Mangabeira) was exported by the River Parana through Paraguay.

According to the United States Consul at Buenos Ayres, "in the forest of the Gran Chaco, as also in the Republic of Paraguay there is a tree whose name in the Guarani language is Mangá-icé (probably *Hancornia speciosa*), which is everywhere very abundant, from the sap of which a most excellent gum elastic is obtained . . . the industry is carried on to a considerable extent but in a very primitive way in Villa San Pedro, Paraguay."

MATTO GROSSO RUBBER.

Matto Grosso is the second largest Brazilian state, and more than twice the size of the German Empire. Of late years rubber has been largely exported from the State. That obtained from the northern part is shipped from Para, and is known as Virgin sheet and *Para blanc*

(Fr.); also under its general name of Matto Grosso rubber. The interior of the mass is of a rich cream colour marbled with irregular dark lines. It is doubtless yielded by one or other of the numerous species of *Hevea*. Another sort of Matto Grosso rubber is obtained from the southern part of the State and, as already mentioned, it is probably obtained from *Hancornia speciosa*.

COLOMBIAN RUBBER.

From the singular geographical position of the United States of Colombia, it is evident that they produce rubbers obtained from several plants. In Panama, Darien, the Magdalena Valley, and the western coast as far as the frontier of Ecuador, the principal rubber plant is *Castilloa elastica*, yielding Darien, Cartagena Barranquilla and Guayaquil rubber of commerce. In the extreme south-eastern parts, where arise numerous tributaries of the Amazon there are probably found some species of *Hevea*, whose rubber is exported from Para.

Besides these there is a rubber produced in the Colombian Andes at elevations of 6,000 to 8,000 feet, known in commerce as "Colombia Virgen" or "Colombian Scrap." It is described as produced in the department of Tolima, in the interior of the country, it is "yellowish, clean, and does not require to be pressed;" also "as superior to the coast rubber, and worth in 1890 3s. to 3s. 3d. per pound." It has been chiefly exported to the United States market, and realised prices second only to Para rubber. The plant yielding at least some of this rubber has been identified as one of the numerous varieties of *Sapium biglandulosum*. Of late years the trees have been ruthlessly destroyed, and there is now but little rubber exported (*Kew Bulletin*, 1890, pp. 149-158, and 1892, p. 70).

VENEZUELAN RUBBER.

The rubber exported from Bolivar on the Orinoco is probably obtained from the upper waters of the Rio Negro and, as stated by Dr. Ernest, is yielded by a species of *Hevea*. *Hevea benthamiana* appears to be cultivated in one locality in Venezuela. There are doubtless other rubber-yielding trees to be found in the country. A small specimen of rubber was lately received from Venezuela (through Mr. J. H. Hart, of Trinidad) of excellent quality. The plant yielding it was stated to cover immense tracts of country. The only clue submitted was a single seed. This was of a bright chestnut colour resembling in size and

form that of *Manihot Glaziovii*, but not mottled. There is little doubt that the plant is a species of *Manihot*, but it is impossible from the seed alone to determine it.

BRITISH GUIANA RUBBER.

There are several species of *Hevea*, of which *H. pauciflora* and *H. dubia* have been described, growing in British Guiana. These trees are found in the upper basins of the Essequibo and Mazaruni rivers. A plant known as Macwarrie-balli (*Forsteronia gracilis*), a climber closely allied to the Milk-wythe of Jamaica is likely to yield a useful rubber, also a species of *Ficus* known as Cumakaballi and the Touchpong, probably *Sapium biglandulosum*. So far the rubber trees of British Guiana have not been fully investigated. It has been suggested that where species of *Hevea* are fairly plentiful, natural plantations should be established; also that *Hevea brasiliensis* might be introduced for cultivation on interior river lands.

JAMAICA RUBBER.

A climbing plant, known as the Milk-wythe of Jamaica (*Forsteronia floribunda*), found in the interior woods of the parishes of Manchester and St. Elizabeth, yields an excellent rubber. Attention was first drawn to the plant by the writer in the "Reports of the Botanical Departments," 1883, p. 17, and 1884, pp. 46-47. A sample of the milk was received in this country in 1888. The rubber extracted from it was pronounced to be "remarkably good." Further, "in colour and strength it approached more nearly to the better descriptions of Para rubber; mixed with sulphur and treated, it vulcanised perfectly, and was solid, firm, and strong" (*Kew Bulletin*, 1888, p. 294).

OTHER RUBBER PLANTS.

Of other New World and rubber plants, mention may be made of the Cow tree or "Palo de Vaca" (*Brosimum Galactodendron*), of tropical South America. It is a large forest tree yielding a milk commonly used as food. It contains some caoutchouc but mixed with 30 per cent. of resin. According to Humboldt a plant known botanically as *Siphocampylos Caoutchouc*, growing in the valley of the Mayo river in Colombia, yields rubber, as also *S. Jamesonianus*, of Ecuador. The latter is one of the several plants called "Jéve." *Couma utilis*, another "Cow tree," native of North Brazil near Manos, yields a milky fluid used for waterproofing purposes. A similar use

according to Spruce, is made of the milk of a tree called "Cumai," frequent on the Rio Negro and Vaupes.

General Notes.

ANTIQUÉ FURNITURE IN FRANCE.—The United States Consul at Marseilles, in a recent report to his Government, calls attention to a law dealing with curio and antique furniture dealers, which has lately been issued. This law may be of service to the many strangers who visit France with the expectation of buying articles of the above description, possessing artistic or historic value. The vital feature of the law is the obligation now resting upon all brokers, dealers in old furniture, linen, clothes, jewels, books, dishes, arms, and other articles, to keep an official register, signed by the commissary of police or the mayor, containing "day by day, without blanks or erasures, the name, surname, character, and dwelling of those with whom the said broker has contracted; also the nature, quality, and price of all said merchandise, and said register must be forthcoming on demand." Penalties are prescribed for violation of the foregoing provision, the object of which is to prevent fraud in the exchange of old and second-hand goods, especially such as are sought by collectors.

Obituary.

SIR F. D. BELL, K.C.M.G., C.B.—The death of Sir Francis Dillon Bell, formerly Speaker of the New Zealand House of Representatives and Agent-General for New Zealand in England, is announced by the Sidney correspondent of the *Times*. Sir Francis who was the son of Mr. Edward Bell, of Horsey, was born in 1822, and at the age of 17 entered the service of the New Zealand Company. On the surrender of the charter of the company in 1851 he became Commissioner of Crown lands, and five years later he formed (in conjunction with Mr. Sewell) the first responsible Ministry for the Colony, in which he held the office of Colonial Treasurer. In 1856 he was appointed to the office of Commissioner of Land Claims. He was subsequently elected Speaker of the House of Representatives, an office which he held for five years. In 1881 he succeeded Sir Julius Vogel as Agent-General in London. He took an active part in the Colonial and Indian Exhibition, and in 1887 he was a delegate to the Colonial Conference. He retired in 1891 and received the thanks of the Legislative Council for his services. Sir Francis Bell was elected a member of the Society of Arts in 1881, and was a member of the Council from 1884 to 1887. He was a Vice-President from 1888 to 1891, and on several occasions he took the chair at the evening meetings.

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CANTOR LECTURES.

SOURCES OF COMMERCIAL INDIA-
RUBBER.

BY DR. D. MORRIS, M.A., C.M.G.

Lecture II.—Delivered April 25, 1898.

AFRICAN RUBBER.

The development of the rubber industry in the equatorial parts of Africa is one of the most remarkable incidents in recent years. As regards the world's commerce in rubber Africa now occupies the second place.

Up to within a very late period all the plants yielding African rubber belonged to the single genus *Landolphia*, containing a group of woody climbers with sweet-scented flowers and edible pulpy fruits. In 1894 a valuable rubber-tree, a *Kickxia*, was discovered in the colony of Lagos, and afterwards found to extend along the whole of the littoral of West Africa from Sierra Leone to the Gaboon. More recently still a new and singular rubber-yielding plant of a semi-herbaceous character has come into prominence in the Congo State. This is said to cover immense tracts of dry and grassy country in southern equatorial Africa. It reaches as far as Mossamedes in lat. 15° S.

The chief districts of export of African rubber on the West Coast are Senegambia, Sierra Leone, Gold Coast, Lagos, Niger Territory, Congo State, Gaboon, Loanda and Benguela. On the East Coast, Mozambique, Madagascar, Zanzibar, Nyasaland and German East Africa are all important rubber-producing districts. As might be expected, the rubber obtained from these widely-extended districts varies greatly in character. The distinguishing terms used in commerce are based either on the form and colour of the rubber or the district from which it is exported.

The best sorts are generally obtained from

Mozambique and Madagascar. They are in the form of balls or sausage; the latter consists of spindle-shaped masses wound around a piece of wood which is eventually removed—hence “woodless-sausage” or “skins.” Both Mozambique and Madagascar rubber is of a pinkish colour. Some of the latter is, however, black and of an inferior character. “Niggers” or “negro-heads” are balls of scrap rubber; “twists” are sausage-like masses composed of rubber strings; “thimbles” are in small cubes, “lumps,” “flakes,” biscuits, “straps,” “strips” and “tongues” are so called from the shape. There are numerous other varieties, such as “red and black twists,” “red and black Portuguese thimbles,” “upper Congo balls,” “Sierra Leone large ball,” “Uelle slabs,” “Cape Coast lump,” while a “potato rubber,” so called from its shape, comes from Loanda and Benguela.

The following Table shows the rapid increase in the imports of African rubber into the United Kingdom during the last eighteen years:—

Value of Imports of Rubber from East and West Africa (including Madagascar), distinguishing those from Foreign and British Sources.

	1878.	1888.	1896.
	£	£	£
Foreign	86,752	233,250	206,972
British	38,343	182,176	844,840
Total	125,095	415,426	1,051,812

Before describing in detail the various rubber-yielding plants found in Equatorial Africa, it is desirable to discuss the distribution of the most important plants which, as already stated, belong to *Landolphia*. This genus was named after M. Landolphe, who commanded the West African Expedition to which P. de Beauvois was attached as botanist. The latter described the first known species, *L. ovariensis*, the celebrated “white rubber vine” of the West Coast.

The Landolphias belong to the natural order Apocynaceæ, which includes not only the African rubber, but also such important rubber-yielding plants as Mangabeira (*Hancornia speciosa*) of South America, and the Willughbeias and *Leuconotis* of the Malay Archipelago. Monteiro (“Angola,” I. p. 31) describes the Landolphias, as they present themselves in an African jungle, as follows:—

"Creepers of all kinds, attaining a gigantic size, here almost monopolise the vegetation, clasping round the biggest trees and covering them with a mass of foliage and flower, and forming most exquisite festoons and curtains, as they web, as it were one tree to another in their embrace. No words can describe the luxuriance of these tree creepers, particularly in the vicinity of the shallows, rivers, and rivulets of the interior. Several trees together, covered from top to bottom with a rich mantle of the India-rubber creeper (*Landolphia florida*?), with bright, large, dark-green leaves somewhat resembling those of the Magnolia, thickly studded with large bunches of purest white jasmine-like flowers, loading the air for a considerable distance with its powerful bitter almond perfume, and attracting a cloud of buzzing insects, form altogether a sight not easily forgotten."

The *Landolphias* are widely distributed over the whole of tropical Africa, and extend from 16° N. lat. to 23° S. lat. They are found in practically all the forest regions, and consist of numerous species. At least ten of these are valuable rubber-yielding plants. Two species, *L. florida* and *L. petersiana*, are found on both the East and West Coasts, and probably extend across the great equatorial forest region. The rubber plants of the East and West Coasts may be arranged as follows:—

West Coast—*L. florida*, *L. petersiana*, *L. owariensis*, *L. senegalensis*, and *L. tomentosa*.

East Coast—*L. florida*, *L. petersiana*, *L. Kirkii*, and *L. madagascariensis*.

A classification according to the size of the flowers and leaves would be as follows:—

1. Species with large flowers.—*L. florida*, *L. madagascariensis*, and *L. petersiana*.
2. Species with small flowers and large leaves.—*L. senegalensis*, *L. owariensis*, and *L. tomentosa*.
3. Species with small flowers and small leaves.—*L. Kirkii*.

WEST COAST RUBBER PLANTS.

1. *Landolphia florida*, Benth.—This was long known as a handsome flowering plant before its commercial value was known. It was first described as *Vahea comorensis* by Bojer in 1836, from the Comoro Islands to the north-west of Madagascar. It was afterwards found on the Niger by Captain Trotter, in 1848, and then by Madame Tinne in the Soudan, in 1867. Since then it has been found in many places on both the East and West Coasts, from Senegambia to Benguela on the west coast, and from Uganda to Mozambique on the east, occurring in forests near the coasts as well as in the interior, but varying slightly

in the hairiness of the flower panicles in each locality. Living specimens were received at Kew in 1878, from Sir John Kirk. These, after climbing to the roof of the Palm-house, flowered in 1887, "powerfully scenting the air with their delicious fragrance." A coloured plate was given in the "Botanical Magazine," t. 6963, with a description by Sir Joseph Hooker. The latter states:—

"The first notice of the *Landolphia* yielding India-rubber that I have found is by Col. (now Sir) J. A. Grant, in the appendix to *Speke's Journal* (p. 639), repeated in an elaborate account of his collections published in the Linnean Society's Transactions (xxix. 107). In this he says of *Landolphia florida*, 'A woody climber, named M'hoonga (Kis), found at Madi, Derembe, in a shady spot by a rocky burn. Its trunk travelled like a boa constrictor along the ground till it found a tree to climb up, and was twenty-five inches in circumference; ascending to the topmost branches, it threw down pendants of foliage and clusters of lily-white, scented flowers. The milk if rubbed upon the skin adheres like bird lime and can scarcely be rubbed off The Wahiao people make playing-balls from the juice, and consider its rubber to be the most adhesive known.'"



FIG. 13.—MBUNGU RUBBER (*Landolphia florida*) OF EAST AND WEST AFRICA.

Portion of shoot, showing tendrils and leaves. Also a panicle of the sweet jasmine-like flowers.

On the Niger, according to Barter, its fruit, which is very sour, is eaten by the natives under the name of *Aboli*.

The form in which the rubber comes into commerce is somewhat peculiar. It is accounted for by the method of collection which has been described as follows: "Every part exudes a milky juice when cut or wounded, but this will not run into a vessel placed to catch it, as it dries so quickly as to form a ridge on the wound, which stops its further flow. The blacks collect it by making long cuts in the bark with a knife, and as the milky juice gushes out, it is wiped off continually with the fingers and smeared on their arms, shoulders and breast, till a thick covering is formed. This is peeled off their bodies and cut into small squares, which are then said to be boiled in water."

In the English markets it appears as more or less agglutinated masses of small cubes, of which there are specimens in the Kew Museum under the name of "thimble rubber" (Kew Report, 1880, p. 39).



FIG. 14.—WHITE RUBBER VINE (*Landolphia owariensis*).

(1.) Flower. (2.) Section of ditto. (3.) Stigma. (4.) Fruit.

2. *L. owariensis*.—This has a considerable latitudinal range on the West Coast, and extends from Sierra Leone to Angola. It is the white rubber vine of the English, the "Ninge" of the French Congo, and "N'dembo" of the Gaboon. Specimens of stems from this species

in the Kew Museum are marked, "yields the best Sierra Leone rubber; incisions are made in the stem, and the milk is coagulated with lime juice." A sample of Congo rubber from this plant "was valued in London in 1891 at 1s. 10d. to 2s. per pound." There is also a specimen of rubber from *L. owariensis* from Accra (Gold Coast), contributed by Mr. R. Murray Rumsey, R.N., in 1882.

This species was collected on the Niger by Barter, and near the mouth of the Congo by R. C. Phillips, who states that it bears the native name of "Mvoochi." A form not specifically distinguishable was found by Schweinfurth in North Central Africa. He remarks ("Heart of Africa," i., 192) that "it is well known in the Guinea trade for its production of caoutchouc." From the fruit "the sourness of which exceeds that of the citron," the natives of Djurland manufacture "a beverage refreshing as lemonade" (Kew Report, 1880, p. 38).

3. *L. Mannii*.—This is a very distinct species collected by Gustav Mann at Corisco bay (Lat. 1 N.), and at present known only from one other locality, viz., Barombi station in the Cameroons. Mann describes it as a climber 20 feet high, and yielding caoutchouc. Specimens of the large globular fruits are in the Kew Museum.

4. *L. petersiana*.—This is the "Tonda" or "Etonda" of the Gaboon, and is found also on the Congo. It is a wide-climbing plant, with the young branches covered with a rusty down and white tubular flowers. The globular-rusty fruit has an acid edible pulp. The rubber is prepared in a different way from that yielded by any other species. The milk is gathered in a fluid state and coagulated by heat. The product is generally regarded as not so good as that of *L. owariensis*.

5. *L. senegalensis*. Radlk.—This is believed to be the "Tol" or "Tohl" of Senegambia, the "Taul" of the English at the Gambia, and possibly that which is known to the Bambaras under the name of "Goe" on the Lare. According to Baucher this is the *Landolphia* which furnishes the greater part of the caoutchouc of the Cazamance river district (Senegambia), and of the Rio Nunez of Sierra Leone, and perhaps of the Gaboon. It is to be noticed, however, that *L. Heudelotii* is mentioned by de Weyre as being found also in the same localities, and under almost identical native names.

Having briefly described the principal species

of *Landolphia* known to yield rubber on the West Coast, it may be interesting to furnish similar particulars of other india-rubber plants found in this part of Africa.

6. *Ficus Vogelii*.—During the years 1888-90 the subject of obtaining commercial rubber from the "Abba" trees of West Africa was very enterprisingly taken up by Sir Alfred Moloney, then Governor of Lagos. The difficulty at first experienced was the large percentage of resin in the milk. In experiments

not suitable to be used alone in any form and troublesome to work in the mixing machines, the present samples were free from these objections. In fact 'Abba' rubber as prepared by Mr. Higginson was capable of being used alone for many purposes." Nothing further appears to have been done to utilise the rubber of this tree. As it is found distributed over extensive areas in West Africa, grows to a large size, and is readily propagated by cuttings, it is possible, when other sources



FIG. 15.—KICKXIA AFRICANA.

Tree yielding "Lagos silk rubber." (1.) Flowering branch (two-thirds natural size). (2.) Bud. (3.) Segment of calyx, with glands at the base. (4.) Corolla, cut open with style, and stigma removed. (5.) Anther, front view. (6.) Pistil with disk (d). (7.) A pair of follicles (fruit)—two-thirds natural size. (8.) Seed. (9.) Transverse section of seed (f. testa, a. albumen, c. cavity). Nos. 2 to 6, and 8 and 9, all enlarged.—[From the *Kew Bulletin*.]

carried on in 1890 by Mr. W. Higginson it was found possible to prepare rubber in large quantities at a cost of less than 1s. per lb. A report on samples forwarded to this country was as follows:—"The rubber was free from impurities, and had not suffered any deterioration in transit, two points of considerable importance in regard to African rubbers as usually received in this country. In the next place, while former samples were reported as

are becoming exhausted, that this plant will repay regular cultivation.

LAGOS SILK RUBBER.

7. *Kickxia africana*.—A new rubber-yielding plant suddenly came into notice in the colony of Lagos in 1894. This proved to be a handsome tree, locally known as Ire, Ireh, or Ereh. It belongs to the same natural order as the *Landolphias*. The particulars

respecting it were gradually accumulated at Kew until at last it was determined to be *Kickxia africana*, Benth, a tree widely distributed in West Africa from Sierra Leone to the delta of the Niger, the island of Fernando Po, and the Gaboon.

The previous information was very scanty. It is believed that rubber was first obtained from it on the Gold Coast in 1883. In 1888 seeds of it were introduced to Europe as a substitute for *Strophanthus* seed, and stated to be worth 72s. per pound. They were called "India-rubber" seeds, but nothing further could be obtained respecting them. The following extracts are taken from the *Kew Bulletin*, 1890 (pp. 242-247):—

"In September, 1894, Kew received from Captain Denton, C.M.G., two pieces of the trunk of the Lagos rubber-tree, each about 10 inches to a foot in diameter, scored with the marks of the rubber gatherers. They were sent as the 'female' rubber-tree, a name we learn that is locally applied to the *Kickxia africana*, Benth. It is thus distinguished from *Holarrhena africana*, quite a different plant, which is fancifully called the 'male' rubber-tree. The latter is also an Apocynaceous plant, but not known to yield any rubber."

"In tapping the trees the bark is first cut in a vertical direction from the bottom to the top. This single line is about $\frac{1}{2}$ to $\frac{3}{8}$ of an inch broad, and deep enough to reach the inner bark. This forms the main groove, on each side of this two series of oblique grooves about two feet apart are cut, each running into the main groove. The side grooves are made, beginning at the top, and gradually reaching the base of the tree. All the milk exuding from the lateral grooves will find its way into the main groove and so ultimately reach the bottom, where a vessel is placed to receive it. When sufficient milk has accumulated it is then collected and made into rubber.

"The methods adopted for coagulating the milk are then described. These are at present of two kinds, viz.: 'the cold process' and 'the heat process.' The cold process is chiefly practised by the Fanti men introduced from the Gold Coast. A cavity is excavated in the trunk of a fallen tree so as to form a cistern of the capacity necessary for holding the milk collected during several days. Into this the rubber gatherers pour the milk, after straining it, from day to day until it is quite full. It is then covered with palm leaves and left for 12 to 14 days and sometimes much longer, depending on the season, until most of the watery portions have either evaporated or sunk into the wood. After being kneaded and pressed together the rubber thus obtained has a dark brownish colour, with the inner portions of a slightly lighter colour. Such rubber is known locally as 'silk rubber.' The local price is from 10d. to 1s. 2d. per pound. The heat process is the one generally adopted

by the natives of Lagos. This is much simpler in working, as it disposes of all the milk collected at the close of each day. After being strained the milk is placed in a vessel and boiled. The rubber begins to coagulate almost directly the heat is applied, and after the boiling is over is removed in a somewhat sticky condition, owing to being burnt, and of a blackish colour. The local price of this rubber is from 9d. to 1s. per pound. It is pointed out that the heat process, though simpler, impairs the quality of the rubber and is calculated to injure the industry. It is probable that if the heat process were somewhat modified the results would not be so injurious. An experiment was tried at the Botanic Station to coagulate the milk by heat, but not applied directly to it. The result was much more satisfactory. The rubber came off a milky-white colour, and after being pressed it was clean and firm without being sticky.

"The history of this new rubber industry in Lagos is full of interest, and illustrates the wonderfully rich resources of the vast forests of West Africa. It shows also very clearly how largely these resources can be developed by judicious and intelligent action on the part of the Government.

"Should the new rubber *Kickxia* continue of commercial value, there is no doubt that it will eventually be possible to establish regular plantations, and thus make the industry a permanent one. It has always been seen that owing to the climbing habit of the species of the *Dalbergia*, which have hitherto yielded African rubber, it was not practicable to cultivate them in regular plantations as they required the support of other plants, and when once tapped many years would have to elapse before they would be fit to yield another crop. With the *Kickxia* these practical difficulties disappear."

According to M. Chalot *Kickxia africana* has been found lately in Gaboon. Specimens have been measured 1 metre in circumference and 12 to 15 metres high. Each tree is estimated to yield annually, without any injury, at least 1½ lbs. of rubber.

NEW ROOT RUBBER.

8. *Carpodinus lanceolatus*.—From this and allied species is obtained the new African root-rubber. In the Report of the U.S. Consul at St. Paul de Loanda in 1891, mention is made of a new source of rubber discovered in 1888 in the district of Bihée. It was believed to be yielded by a "tuber," but at that time its botanical name and the method of extracting the rubber were unknown. It was stated "that a good quality of rubber was produced, and that the plant must be found in immense quantities, as it was to the discovery of it that Benguela owed the enormous increase in its exports as compared with previous years."

Nothing further was heard of this new rubber plant until last year, when through the investigations of Professor Laurent of the Agricultural Institute at Gembloux, Belgium, who spent some time in Congo territory, were obtained not only specimens of the plant and the rubber, but very interesting particulars respecting its habit and distribution. These were published with a woodcut in the Berlin "Tropenpflanzer" (1897, pp. 133-138).

There are two plants concerned, *Carpodinus lanceolatus* and *Clitandra henriquesiana*, both belonging, like the Landolphas, to the natural order Apocynaceæ. The interesting point is that these are neither trees nor shrubby climbers as other rubber-yielding plants in tropical Africa. They are described as low plants with slender, semi-herbaceous stems one to two feet high, and white aromatic flowers. They are found in great abundance on the sandy expanses in the Kwango district south of Stanley Pool, and from this region alone it is said that 500 tons of rubber are produced yearly. Possibly, also, a part of the rubber from the Cabinda district is derived from the same plant. The *Carpodinus* is known as "Otarampa," the *Clitandra* as "Bihungi." They are very abundant in the open grassy country of the Congo State and extend to Portuguese South-west Africa as far as lat. 16° S. They are also found inland in Ambuella and in the highlands of Benguela and Mossamedes. They therefore possess an extensive distribution in tropical Africa, and may be found still further to the eastward.

Although the stems contain rubber the larger share is at present obtained from the creeping underground stems (rhizomes). These are about an inch in diameter and the natives extract the rubber by rasping them in water and then boiling. In this way a large quantity of vegetable *débris* is taken up with the rubber and the quality is thereby impaired. The last price quoted was 2s. 6d. per pound.

The discovery of these remarkable rubber plants shows how far we still are from knowing the full extent of the sources whence this valuable product may be obtained. It is possible that these new plants may be available for cultivation, and give returns earlier than other rubber plants. They could evidently be easily propagated by means of pieces of the rhizomes, and although it would be necessary to destroy many of the plants to obtain the rubber, there is a probability that numerous pieces of the rhizomes could be left in the ground to carry on the cultivation to another year.

There are probably several other plants that yield rubber in West Africa. The "Kpokpoka" tree of Sierra Leone, *Tabernamontana crassa* with large double fruits as large as a child's head, is supposed to yield some of the rubber exported from Sierra Leone and the Gold Coast; but nothing authentic is known of it. The plant is, however, grown experimentally



FIG. 16.—PLANTS YIELDING THE NEW ROOT-RUBBER OF THE CONGO AND LOANDA.

A. *Carpodinus lanceolatus*, one-tenth natural size, showing underground stem or rhizome from which rubber is obtained. B. Upper part of shoot of the same species, one-sixth natural size. C. Single flower cut open on one side, three-quarters natural size. D and E. *Clitandra henriquesiana*, one-tenth natural size.—[From *der Tropenpflanzer*.]

both at the Botanic Gardens in Ceylon and Trinidad. Another species of *Tabernamontana* is the "Pao Cadeira" of Sao Thomé; from this rubber is extracted according to Ficalho. According to Dr. Warburg, in the northern part of the Cameroons the milky juice of an undetermined tree yields the rubber obtained from that region.

SOUDAN.

The French in the Soudan are developing the rubber industry of that region. It has lately been notified that rubber would be received in payment of taxes. It is collected at Kayes, the capital, and then sold by auction. The value exported in 1896 was £6,000.

GAMBIA.

The exports of rubber from the Gambia began in 1882 when they were of the value of £114. In 1884 they had risen to a value of

£23,142. Since that time they have greatly fluctuated, but the tendency has been to diminish owing to the reckless destruction of the vines.

SIERRA LEONE.

According to a recent report of the Governor, there are large tracts of forest land with rubber trees (*Landolphia* and *Kickxia*) existing in the colony. The most valuable plant is *Landolphia owariensis*, known as "Lilibue." The next is *L. florida*, known as "Nofe," which yields a dark rubber prepared with lime-juice. *Kickxia*, known as "Kewatia," is estimated in one district alone to be distributed over an area of 600 square miles.

GOLD COAST.

Rubber has been exported from this colony since 1878. Experienced rubber collectors were introduced from Sierra Leone just as recently similar men were introduced from the Gold Coast to Lagos. The value of the rubber industry at the Gold Coast during the years 1894-96, inclusive, was as follows:—

Year.	Quantity.	Value.
	lbs.	£
1894.....	3,027,527	232,550
1895.....	4,022,385	322,070
1896.....	3,735,439	313,817

It is generally recognised that the development of this important industry is almost entirely due to the initiation of Sir Alfred Moloney.

LAGOS.

The rubber industry at Lagos as already shown was started as lately as 1894. At the close of the year 1895 it had attained a value of £269,893. This represented an export of 2,263 tons. Latterly the exports have greatly fallen off (about one-third), owing to the excessive bleeding of the trees.

NIGER PROTECTORATE.

The exports of rubber have only lately assumed importance. The following returns have been published:—

Year.	Quantity.	Value.
	lbs.	£
1892-93	332,433	17,610
1893-94	540,772	27,782
1894-95 ....	....	13,282
1895-96	308,309	11,787

CONGO STATE.

India-rubber plants are found in all parts of the Congo State. More than one-half the external trade is in rubber. The development of the exports in recent years (largely due to the discovery of the root-rubber) may be illustrated by the following Table:—

Year.	Quantity.	Value.
	lbs.	£
1887.....	66,248	4,671
1891.....	180,072	13,069
1892.....	1,014,720	73,664
1897.....	4,480,000	114,000

LOANDA.

The Portuguese possessions in South-west Africa have long been regarded as yielding a large share of African rubber. It is chiefly shipped to Lisbon. Mr. Consul Pickersgill, in 1896, stated "rubber is now brought a long distance from the interior, and Benguela has the largest movement in this trade." The quality is good but very dirty and full of bark. It is known in European markets as Loanda "niggers," first and second quality. Some of the more enterprising planters are turning their attention to the cultivation of the rubber plant, but up to the present no results have been given. The total exports from Loanda, and Novo Redondo, Ambriz, Benguela, and Mossamedes during the two years 1894 and 1896 were 4,296 tons, of the value of £659,532.

EAST COAST RUBBER PLANTS.

On the mainland of the East Coast it would appear that rubber is yielded almost exclusively by climbing species of *Landolphia*. Apparently there are no trees similar to *Kickxia*, *Ficus*, and *Tabernemontana* existing, or at least utilised, there for rubber production.

1. *L. Kirkii*.—This *Landolphia* is characterised by having both small flowers and small leaves. The fruit is round, smooth, and pear-shaped. It is named after Sir John Kirk, who, during his long service as Consul-General at Zanzibar, practically created the rubber trade on the East Coast of Africa. The following interesting particulars respecting this species are taken from the "Kew Report," 1880, pp. 39, 40.

Dr. Kirk describes it as "the narrow-leaf *Landolphia*, which yields the best rubber of the Zanzibar coast." He adds, "as far as I

could discover, this is the only species considered to be of value by the people of the Dar es Salaam district It undoubtedly yields by far the greatest quantity, and also the best. Again, when we consider the wide region over which this plant grows, its abundance in many places, and the facility with which so indestructible a substance can be collected, I think in time this will become one of the regular exports of East Africa." The extract from a further letter of Dr. Kirk's, given in the Kew Report for 1877, p. 32, as well as later statistics quoted below, will show how rapidly Dr. Kirk's expectations have been realised. In a report made to the Foreign Office in 1880, Mr. F. Holmwood, the Vice-Consul at Zanzibar, gives the following account of an improved mode of collecting India-rubber from *mtiri* (apparently another mode of spelling *matere*, *L. Kirkii*):—

"The process consisted in cutting clean slices of bark from the trunk and branches, from 3 to 10 inches in length and from $\frac{1}{2}$ to $\frac{3}{4}$ inch in breadth. The cuttings were made sometimes from one side only, but generally they were scored all over the tree—about half of its trunk being removed. The method of making the balls of rubber, which average two inches in diameter, is as follows:—A quantity of milk is dabbed upon the forearm, and being peeled off forms a nucleus. This is applied to one after the other of the fresh cuts, and being turned with a rotary motion the exuding milk is wound off like silk from a cocoon. The affinity of this liquid for the coagulated rubber is so great that not only is every particle cleanly removed from the cuttings, but also a large quantity of semi-coagulated milk is drawn from beneath the uncut bark, and during the process a break in the thread rarely occurs.

"By working hard one person can collect 5 lbs. of rubber per diem, though an average is only half that amount. I was assured, however, that in the interior, where the trees run large, it is no uncommon thing for one man to collect 7 lbs. or even 9 lbs. in a day. . . . The regular season for the collection of the India-rubber lasts from about the middle of May till the first week in December. This has little connection, however, with the state of the tree, but is owing to the natives being generally engaged during, and for some time after, the rainy season in cultivating their lands."

Later he reports:—

"In the district of Mungao and Kilwa alone india-rubber has created a new trade, which finds profitable employment for all those classes whose means of subsistence came to an end with the suppression of illegal slave trade. The total export from these places now (1880) exceeds 1,000 tons annually. Since last season the price has risen from £140 to £250 per ton, and there seems no reason to suppose that it will ever again fall to the former figure."

2. *L. florida*.—This species has already been described under the rubber plants of the West Coast. It appears to be equally well known on the East Coast, and extends into Central Africa, where as in Nyasaland it yields good rubber. Very valuable information was contributed to Kew, respecting this plant, by Sir John Kirk and others. There appears to have been no doubt as to the value of the rubber in the minds of those acquainted with it in this part of Africa. On the other hand, de Wevre quotes numerous authorities, showing that the rubber in some districts, at least, is "hard, brittle, and resinous, and absolutely useless for commercial purposes;" if used at all, it is used only for purposes of adulteration.

The following information is taken from the "Kew Report," 1880, p. 41:—In 1879, Dr. Kirk made to the Foreign Office "a report on the india-rubber plants of the coast near Dar es Salaam." He stated:—

"It has been known for many years that the jungles on the mainland contained almost everywhere an abundance of rubber-producing lianas, and on my first arrival in Zanzibar an attempt was made, at my representation, to induce the people of Dar-Salam to collect it; at that time, however, everyone was engaged in the slave trade, and the experiment in consequence failed. Within the last few years, india-rubber has, however, become one of the chief exports we possess."

Further information is given by Mr. Vice-Consul Holmwood:—

"The 'mbungu' is abundant on the Portuguese coast between Cape Delgado and Ibo, even close to the sea. The rubber does not coagulate quickly, and the Makuas who were collecting it used sand to assist this process, and not, I think, originally for the purpose of adulteration. Here a few balls of this rubber come down in every parcel, and are accepted and weighed with the bulk, but the merchants inform me they would only buy 'mbungu' rubber at a reduction of 25 per cent. in price. . . . The fruit has a very pleasant flavour, and an agreeable acid taste."

3. *L. petersiana*.—This, as the last, is found on the East as well as on the West Coast. The early account of its discovery and of its utilisation as a rubber plant in East Africa, was given in the "Kew Report," 1880, pp. 42-43:—

"In 1879 Dr. Kirk reported to the Foreign Office that it appears, from the further observations of Lieutenant O'Neill, that there exists a third variety of rubber, the produce of a distinct plant, in all probability a new species of the genus *Landolphia*, which grows near Tanga,

on the coast of the mainland opposite Pemba. The mode of preparation of this india-rubber differs essentially from either of the other two kinds, the juice being here gathered in a fluid state by tapping, and coagulated by heat, or in some other way similar to that used in Madagascar or the Brazils. The product is said, however, to be of an inferior quality. . . . The native name given to the plant is *Mtolia* or *Mtoria*, which I have often heard applied to the edible fruit of a plant at Mombasa known to contain rubber but in small amount."

4. A fourth species of *Landolphia* found in East Africa is *L. Watsoni*. This is evidently closely allied, if not identical, with some forms of *L. Kirkii*.

The Portuguese possessions in East Africa have been most productive sources of india-rubber, generally of excellent quality. Mr. Consul O'Neil, in 1885, thus described the industry in the district of Quilimane:—

"Rubber is obtained mostly from the lower districts nearer the sea. There are two qualities, differing in the method of preparation. The better is that drawn from cuts made in the stems of vines and made into balls without further preparation. The inferior quality is got by boiling the rubber-bearing stems and roots. It is white, contains much moisture, and commands a lower price than the other. The supply of rubber continues to be maintained but cannot be expected to last very long, as in some districts the vines have all been destroyed by the reckless way of gathering employed by the natives. It has more than once been proposed to try systematic planting of rubber trees, but nothing has yet been done. There is no doubt that the supply could be increased, as well as made more certain, were cultivation gone into systematically, and the gathering of the rubber not left to the mercy of the natives. The total export in 1885 was valued at £1,450; in 1884 it was £2,800."

Further south, at Beira, Mr. Consul Ross in 1893 furnished the following information:—

"During 1893, 24 tons of india-rubber were exported, chiefly by way of experiment, but the prices paid on the coast, and the expenses connected with such a trade left no margin for profit, and this business is in consequence being neglected. The india-rubber is of good quality, but its value is much diminished by the custom the natives have when gathering it of winding the rubber round sticks, pieces of cloth, or other substances. It is brought for sale in fingers, each of which has to be cut open, and the core removed before export. This, done by hand, is a very slow and somewhat expensive process. If a machine knife of some kind could be introduced to do this work rapidly and inexpensively the trade in india-rubber might be made to pay well. Rubber-producing vines grow most luxuriantly everywhere, even in the town itself. No attempt has been made to introduce

other rubber-bearing plants, or to encourage or organise the trade in any way."

The value of the rubber exported in 1893 was £3,700.

DESTRUCTION OF RUBBER PLANTS.

The rapid destruction of the rubber vines in East Africa has long been deplored. Mr. Vice-Consul Holmwood, in 1880, says "it is admitted that while three years ago the supply of india-rubber was altogether derived from the country within 50 miles of the coast, the great bulk was now procured from Mahenge and Ubena, countries distant 150 to 200 miles from Kilwa, the supply from the more adjacent districts having, moreover, greatly fallen off, and in some instances entirely ceased." Mr. Sketchley states, "the natives who alone are the producers have to penetrate deeper and deeper into the forests for each year's supply."

Consul O'Neil remarks:—

"It is curious to note the marvellously rapid development of the india-rubber industry. In 1873 only £443 worth of india-rubber passed through the Custom-house of Mozambique; in 1876 it reached the value of £22,198; and in 1879 it exceeded £50,000. It would seem now almost to have reached its climax, while the present rude method of collecting this produce prevails, and until communications with the interior are properly opened up, for the careless cutting of the tree by the untaught hands of the natives has resulted in the destruction of enormous tracts of india-rubber forest near the coast."

In discussing the possibility of preserving the rubber vines of British Central Africa, Mr. Alexander Whyte offered the following suggestions:—

"A good many more species of *Landolphias* have been described, but those mentioned are, as far as is yet known, the best rubber-yielding sorts. Being natives of the country it will be at once seen how important a part they are likely to play in the development of the natural resources of Nyasaland. There will be certain drawbacks, however, to their being systematically cultivated, owing to the fact of their being creepers and requiring support. It seems to me that the plan most likely to succeed would be to plant up existing forests with the vines, clearing away the useless jungle and undergrowth. The plants, too, now existing, should be carefully conserved, and the natives taught the best method of bleeding the lianas without at the same time permanently injuring them."

In the Province of Tanaland the Germans have already taken official action to prevent the destruction of rubber plants. The rubber-producing tracts have been divided into four areas, two of which are closed for three years at a time to allow the vines to grow up again.

MADAGASCAR RUBBER.

Throughout the moist forest region of Madagascar, rubber-yielding vines are known to abound. There has, as yet, been no proprietorship in the land, and the rubber gatherers have been free to wander at will and destroy the plants. The principal rubber plant is probably *Landolphia madagascariensis* (Vahea gummifera), known locally as "Voacanga" or "Vahy," the *porte gomme* of the French. This is a climbing plant of considerable size, with leathery leaves and rather large white flowers. The fruit is pear-shaped, about 4 inches long, filled with a granular pulp in which the seeds are imbedded. The stem yields an abundance of milk, from which excellent rubber is prepared. Bojer says "it produces a very large quantity of the best kind of rubber, quite as good as Para rubber." The pink rubber, shipped from Tamatave in round balls, is regarded as the best Madagascar sort. The exports in 1885 were of the value of £8,060. According to Coignet, there are three climbing plants that yield rubber in the north-east of Madagascar, as well as a shrub 16 to 19 feet high. Of the climbers, one (probably the plant above described) yields the best rubber, but the natives mix the milk of all the various plants together. The milk of the inferior sorts is coagulated by treatment with salt water or acid, or by artificial heat. By these methods is probably produced the black rubber, shipped from Majunga.

During recent years a considerable rubber industry has arisen in the southern parts of Madagascar. This was due to the discovery, about 1892, of a new rubber plant widely distributed over an extensive tract of country. It was described as an almost leafless shrub, with a large bulbous root, growing only in dry, arid districts. The leaves of what was described by the late M. Raoul of Paris as "the best rubber-yielding plant in South Madagascar," were received at Kew, and an examination of these left no doubt that they belonged to a species of *Tabernaemontana*. Meller, many years ago referred to a closely-allied plant as yielding a "milky juice," and bearing the native name "Dankouti." The discovery of the new rubber plant was described as coming "very fortunately to relieve the Madagascar market which had fallen to so low an ebb that the Tamatave houses were closing their agencies, and were abandoning the trade to small traders."

Mr. Kingdon mentions that the discovery of the new rubber plant in South Madagascar was purely accidental, and entirely due to the natives. Previously, india-rubber had only been procured from *Landolphia* growing in the low-lying parts of Madagascar north of the arid district of St. Mary's. The first samples were sold by the natives at 20s. per hundred pounds; soon after the price rose to 80s. per hundred pounds, but within a short period one trader "cleared £26,000 net profit." As nearly always happens in such cases, the natives recklessly cut down all the plants within their reach, even digging up the roots. It is estimated that within a few years, unless steps are taken to prevent it, this valuable rubber district will be completely exhausted.

(To be continued.)

Miscellaneous.

PORTLAND CEMENT IN ONTARIO.

A grade of Portland cement, claimed to be fully equal in point of excellence to the English, German or even Belgian product, is, according to a recent report of Mr. L. S. Hunt, one of the United States Consuls, made of the natural deposit obtained from the bed of Shallow Lake, in the township of Keppell, Grey County, Ontario, nine miles west of Owen Sound. Its manufacture was begun in 1889 by the Owen Sound Portland Cement Company, and was attended with very great difficulties at first, owing to the fact that but little was known about the processes of its manufacture, and suitable machinery was not readily obtainable. The lake floods every spring and autumn to a depth of several feet, the water leaving, through fissures in the bottom and rock-bound shores, usually about the month of June. Men and teams are then employed to remove a few inches of the waste surface, beneath which the marl lies to a depth of about three feet. Under the marl is found the clay which forms the other ingredient, and which is removed with the aid of a derrick, loaded on waggons, and carried to the factory on the shore of the lake. A large number of men and horses are usually employed for from six weeks to two months, in order to obtain sufficient material for manufacture during the ensuing autumn, winter, and spring. The quality of the cement has been conclusively tested in the construction of the canal at Sault Ste Marie and other waterways, as well as in buildings throughout the Dominion. The supply of ingredients is said to be practically inexhaustible, the lake covering about 600 acres. The daily capacity of the factory is at present 125 barrels, which is to be increased to 300 at an early date. The company was originally formed at Owen Sound, where the principal office is now

located. Although the entire plant was destroyed by fire in 1895, the erection of the present extensive factory was immediately begun, and it is expected to cost, when finished, £25,000. Excellent railway facilities, with sidings to storehouses and coke sheds, are furnished by the Grand Trunk Railway Company. About seven cartloads of coke per week are consumed in the manufacture of the cement.

THE SPONGE FISHERIES OF TRIPOLI.

Tripoli (North Africa) sponges are inferior to those found in the Archipelago and other parts of the Levant, and are of a reddish brown colour. The best quality, viz., that gathered from rocks, is worth from 16s. to 20s. per oke of 2·82 lbs.; the second quality, gathered where sea weed abounds, from 13s. to 16s. per oke; and the third quality, never sought after, but occasionally brought up by the trawlers, from 10s. to 12s. per oke. There are few or no male sponges, *i.e.*, black in colour and totally worthless, on the Tripoli coast. They abound, however, as was proved last year by experiments made by Tripoli divers, in the waters of Malta, where they were found in great depths, their inferiority proceeding, it is alleged, from the sterile character of the sea bed and lack of the proper nutriment necessary for the production of the superior or female sponge. A method is said to have been recently discovered in America by which these male sponges can be made marketable by chemical treatment, but considering the great depths at which they are generally found, and the consequent loss of life, it is doubtful whether it can be made available even if successful. Consul-General Jago states that the Tripoli sponge fisheries extend all along the coast from Farwah, close to the Tunisian frontier on the west, to near Misurata on the east, a distance of about 300 miles. These fisheries were not well explored until 1890, when catches reached the value of £12,000, and in 1893 values of the catches rose to £74,200, to be reduced to £28,000 in 1896. The average annual value since 1890 has been £33,000. The fishermen are Greeks from the Greek islands of Hydra and Ægina, a smaller proportion coming from the Turkish islands of Kalimno, Symi, and Khalki in the Archipelago, these last under the Ottoman flag. Four methods of fishing are employed, viz., the machine boat, or that provided with proper diving dresses and apparatus; the trawler or "gangara;" the harpoon boat; and the common diver, who descends with line and stone. The machine boats, which are five to six tons each, furnished with three or four diving dresses, are divided into two classes, according to quality of dress, the best kind coming from England, and the second, which is cheaper, coming from France. The first-class boat is manned by a crew of 20 to 22 men, of whom 10 are professional divers, and the second-class boat by a crew of 14 to 16 men, of whom 5 to 7 are divers.

The first-class descend to a depth of 25 to 30 fathoms, the second-class to 15 to 20 fathoms, remaining below from five minutes to half an hour at a time, according to depth. The boats keep the sea for two months at a time, being attended by a *dépôt* ship of 50 to 60 tons burden, in the proportion of four machine boats to one *dépôt* ship, a smaller craft being kept in attendance for communication with the shore for provisions, &c., as occasion requires. These *dépôt* ships receive every evening the produce of the day's catch, and supply stores and provisions to the crew. Men from 18 to 50 years of age dive, but those frequenting the Tripoli coast are all young men, few over 30 years. The rate of mortality among them is from 4 to 5 per cent. per season, rarely caused by accidents, but chiefly by the effects of paralysis of the limbs produced, it is stated, by pressure on the spine through fishing in too great depths. Partial or temporary paralysis of the limbs takes place in many cases. In some instances curable by treatment and abstention from work; in others permanent, and necessitating the patients being invalided home. Strange to say, those suffering from this complaint become perfectly well when once they re-descend, to be again attacked on re-emerging from the sea. They receive, besides food, wages at the rate of £20 to £60 per annum of two seasons, the summer season lasting six months, and the winter season four months, according to skill and experience, seamen getting from £13 to £16 per annum, with food. The men are well fed and nourished, receiving when at work one good meal a day—usually taken in the evening. Goat's flesh is largely consumed on account of its digestibility and alleged relief to the respiratory organs. The trawlers or "gangara" are boats of two and three tons each, manned by five to seven men. They trawl under sail by day and night, and drag depths varying from 15 to 60 fathoms. They remain almost constantly at sea, visiting the port now and again on feast days and for the purchase of provisions. The men receive besides food, in some instances, wages of 14 to 20 napoleons per season: in others, they share in the proceeds of the fishery, after deduction made for cost of food, expenses, &c. The action of the trawler is naturally prejudicial to the fishery by tearing and otherwise injuring the sponge, instead of removing it whole and in good condition, as is done by the machine diver. The harpoon boat or "harpun" is of one or two tons burden, manned by three to five men, all of whom come from the Greek islands, and are paid on the share or co-operative system. The harpoon is a many-pronged fork. The common divers, those with line and stone, all come from the Turkish islands of the Archipelago. During the last two or three years the two last classes of fishermen have abandoned the waters of Tripoli, the harpooner finding fewer sponges to be fished in those comparatively shallow waters where alone he can work, and has betaken himself to Crete and Cyprus. The common diver has been scared away by the attacks of the ferocious dog fish, an ugly

black creature, appearing to be all head and jaws, which three years ago bit a diver in two, and desperately wounded two others before they could be drawn up. So far this fish has not attacked the helmeted diver, although often approaching dangerously close, the sounding of the air whistle on deck sufficing, on occasions, to frighten it away. It is sometimes sold in the Tripoli fish market, and the flesh is eaten by a few people, who regard it as a remedy in cases of intermittent fever. The fishery season lasts from April to October, when the majority of the machine boats return home to the islands with their *depôt* ships, taking with them the results of their fishery, and continue their work during the winter season in other and more sheltered parts of the Archipelago. The large bulk of the crop, unbleached and unprepared, is taken at the close of the season to the islands whence the boats come, where long experience in manipulation, combined with cheap labour, prepares them for the European market in conjunction with assortments of other sponges of superior quality fished elsewhere. Thither go the buyers of European houses, who are almost invariably Greek experts. Purchases in Tripoli for foreign account and export direct to Europe take place to the extent of one-quarter to one-third of the entire crop, England taking the largest proportion, followed by France and then Italy. The method of bleaching and preparation practised in Tripoli in respect of a quantity of sponges recently purchased for a European market was as follows:—After being well soaked in the sea for cleansing purposes, they were immersed in a tub of water containing a certain solution of oxalic acid, whence they emerge of a yellowish colour, great care being required that they do not remain in the solution too long, otherwise they become “burnt,” and consequently worthless. After being dried they are worked up in dry sand, then shaken and packed in boxes ready for shipment. The presence of sand in the sponges is said to be necessary to suit the requirements of consumers in certain European countries, who consider it as an infallible test of the genuineness of the article.

INDIAN AND CEYLON TEA.

Messrs. Gow, Wilson and Stanton have issued a diagram showing the fall in the price of British-grown tea, the variations in the value of the rupee, and the approximate return in rupees to the tea planter at the various rates of exchange from 1886 to 1897. They add in explanation of the diagram that on broad lines it may be said that tea is produced in silver currency and paid for in gold currency. In other words, a certain very large per-centage of the price obtained for the article has to be converted into rupees, in which the producing expenses are paid. The higher the gold value of the rupee, the fewer

rupees will the seller of Indian and Ceylon produce get for his sterling price, for when the rupee is worth 1s. 4d. the pound sterling exchanges for only 15 rupees, while it exchanges for 20 when the rupee is worth only 1s. The industries are now of such vast magnitude that a rise of 1d. in the exchange means a difference of more than £400,000 sterling to the producers. The artificial value recently given to the rupee by the closing of the mints by the Government of India, handicaps the growers of India and Ceylon in their competition with their rivals in other tea-producing countries whose currency is ruled by natural laws. The line in the diagram showing the gold value of the rupee calls for little remark. The rupee fell steadily from 1886 to 1888. There was a very slight recovery in 1889, and a rapid rise in 1890, which was due to the passing of the Sherman Act by the United States Congress in that year. A heavy fall took place in 1891, and continued until 1895 when the rupee went as low as 1s. 1 $\frac{3}{4}$ d. for the average of the year. Then, at last, the closing of the mints began to tell, and the gold value of the rupee rose gradually to 1s. 2 $\frac{1}{2}$ d. in 1896, and 1s. 3 $\frac{3}{4}$ d. in 1897. For a few years previous to 1896 the producer had been able to combat the almost persistent fall in the London average price of Indian and Ceylon tea by the decline in the value of the rupee, and notwithstanding a fall of nearly 20 per cent. in the London market price, he received an increased number of rupees for his produce. Since 1895, the planter has not only had to face still lower markets, but has received a less number of rupees, for his local expenditure, in proportion to the rise in exchange which has taken place; and although the fall in the London price was only about 6 per cent., the fall in the remitting power amounted to a figure approaching 20 per cent.

General Notes.

SWISS EMIGRATION IN 1897.—Last year fewer people emigrated from Switzerland than for a number of years past. Over 80 per cent. of the emigrants went to the United States. During the last five years the number leaving Switzerland was 20,132. In 1897, 2,508 emigrated; in 1896, 3,330; in 1895, 4,268; in 1894, 3,849; and in 1893, 6,177. Of those who emigrated in 1897, 1,476 were males and 1,032 females; 396 were under 15 years of age, 1,935 were under 50, and 167 were over 50 years of age. The number emigrating to the United States during 1897 was 2,149. Three went to Canada, six to Central America, 55 to Brazil, 12 to Uruguay, 233 to the Argentine Republic, five to Chile, seven to Australia, 33 to Africa, and three to Asia; 1,870, or about 75 per cent. of the total number, sailed by French lines.

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Notices.**DETERIORATION OF PAPER.**

The Report of the Committee of the Society of Arts on the Deterioration of Paper has now been published, price 1s., and can be obtained on application to the Secretary, Society of Arts, John-street, Adelphi, W.C. Two Appendixes are printed with the Report:—1. Abstracts of Papers on German Official Tests, 1885-96; 2. Précis of Correspondence.

Proceedings of the Society.**CANTOR LECTURES.****SOURCES OF COMMERCIAL INDIA-RUBBER.**

BY DR. D. MORRIS, M.A., C.M.G.

*Lecture II.—Delivered April 25, 1898.**(Concluded from p. 782.)***ASIATIC RUBBERS.**

Of the Asiatic rubbers, the chief sources of supply are obtained from Assam through Calcutta, from Upper Burmah through Rangoon, from the Straits Settlement through Penang and Singapore, from Sumatra, Java, Borneo, and New Guinea.

Assam rubber, the caoutchouc of Indian commerce, imported from Calcutta, is obtained from *Ficus elastica*, Roxb. This is a common parlour plant in this country, and is familiar to every one. When fully developed it attains to the dimensions of a huge forest tree, with low buttress-like roots, and numerous aerial shoots from the branches, forming subsidiary stems—as in the celebrated banyan tree. The leaves in young shoots are up to 12 inches long; in old fruiting branches they are scarcely three inches long. The fruits are arranged in pairs $\frac{1}{2}$ inch long, greenish yellow when ripe.

This tree is often epiphytic, but is readily propagated from cuttings, and is cultivated for shade and ornament in nearly every part of the world. It is a native of the damp forests from the base of the Sikkim Himalaya, eastward to Assam and Arracan. It is usually local in its distribution. It extends beyond Indian territory into that of several neighbouring States, such as Sikkim, Bhotan, and the country of the various independent tribes to the north and east. It is found in Upper Burmah and in some parts of the Malay archipelago.

The rainfall is heavy in these Assam hills, but there are distinct dry and wet seasons. The average temperature for the year is 74° Fahr.

The Assam rubber, both that obtained from Government forests and that imported from beyond the border, is shipped by inland steamers to Calcutta by the rivers Brahmaputra and Meghna. In 1894-95 the out-turn of home rubber was 979 maunds* of the value of Rs. 13,433; of foreign rubber, 2,449 maunds, of the value of Rs. 29,390—total, 3,428 maunds of the value of Rs. 42,823 (or 126 tons of the value, at par, of £4,282).

According to Mr. C. Brownlow not only the aerial roots but the horizontal branches are also tapped. The cuts are made at intervals of a few inches. The tree must be twice climbed, once to cut it, and the second time a day or two afterwards when the gum is dry to gather it. The tears are torn away from each cut, and moulded together to agglutinate into a ball. The quantity that can be gathered from each tree at one cutting is said to be 8 to 10 lbs.

The rubber is shipped from Calcutta in baskets made of split rattans, weighing about 3 cwt. each, and covered with a gunny bag. It has a characteristic mottled appearance, and occurs in the form of balls pressed together, or in irregular masses or slabs. There is an interesting series shown in the Kew Museum from Assam, Burmah, Perak, Singapore, and Sumatra; also from cultivated trees in Ceylon, Egypt and Jamaica.

The earliest writer on the subject of Assam rubber was Dr. Roxburgh, whose attention was first directed to the rubber as a water-proofing material on a vessel containing honey, sent to him in 1810 from Sylhet by Mr. Matthew Richard Smith. Several more recent writers assert that the natives of Assam have for ages been acquainted with the proper-

* A maund = 82 pounds.

ties of gum-elastic, using it to water-proof their baskets and to burn as candles.

The subsequent steps taken to develop a rubber industry in Assam are fully given by Dr. G. Watt in the "Dictionary of the Economic Products of India," iv., pp. 345-548. A sample of Sylhet rubber was sent to Sir David Brewster, which, after eleven years, was found to possess its elasticity, and to be superior to the South America rubber, in lightness of colour and freedom from smell. Dr. Royle in 1838 stated, "there was not the slightest doubt of this rubber becoming an extensive article of Indian commerce." From this time, considerable interest was awakened in Assam caoutchouc. The resources of the districts in which the trees were found were rapidly and recklessly drawn upon, and fears were soon expressed that the industry would be destroyed. Unfortunately also the quality of the rubber was allowed to deteriorate, and it consequently lost its reputation in European markets. The most reliable data on the injury done to the trees, were furnished in an instructive report prepared by Mr. Gustav Mann, Conservator of Forests in Assam, for the year 1868-69. In this it was shown that the contractors, who had bought the privilege of tapping in the Government forests, had no control over the natives, and encouraged the latter to obtain the largest possible quantity of rubber in the shortest time. There was in consequence the most outrageous destruction of valuable trees. Even in other districts, where a less destructive system was pursued, it was found that in time the trees lost their power of yielding milk. Mr. Mann affirmed that continuous tapping for six months, year after year, would kill the trees, and he accordingly urged either that tapping should be reduced to three months a year (January, February, and March), or that a regulation should be made prohibiting the tapping of forests more frequently than once in three years. Mr. Mann concluded, "unless the time of collecting is much more limited, and some plantations are started to provide for future supplies, there will be no more rubber procurable from these forests a few years hence, and the rubber tree will gradually disappear, and a valuable commodity be lost to the public, as well as the revenue derived therefrom to Government."

In 1873, the Government of Bengal decided to start regular plantations of *Ficus elastica* in Assam. The order, issued in 1873, was repeated in 1876, and has been acted upon

with slight interruption until the present time. The Charduar district has proved the best locality for plantations, and in 1884 the total area under caoutchouc trees was 892 acres. This had cost up to that time Rs. 64,351, or Rs. 72 per acre. Later experiments have reduced this cost to Rs. 35 per acre. In May, 1884, directions were issued by the Government of India "that for five years from that date, the Assam plantations should be increased by 200 acres a year. Part of that extension was recommended should be on higher ground than that planted at Charduar."

"At the same time," it was added, "endeavours should be made to induce private persons to plant india-rubber trees on their estates, seedlings being offered by the Forest Department at cost price. It was also suggested that the experimental planting of *Ficus elastica* as an epiphyte might, with advantage, be undertaken by the Forest Department. In a state of nature this plant generally reproduces itself in this way, and although the growth of the seedlings thus raised is slow at first, the trees are said to grow to much larger dimensions ultimately. This method of reproduction is moreover inexpensive, as the seedlings do not require any attention after they have once been deposited in the upper forks of trees." The Government of India also desired "that in order to test the financial results of the cultivation of this rubber, 50 mature trees should be experimentally tapped annually. In the reports of subsequent years, the results of these experiments are fully given. The amount of rubber obtained showed a singular irregularity year by year. It varied so greatly, that while the yield in one year was as much as 26 lbs. per tree, it would fall in another year to a little over 2 lbs. The value in money depended, of course, on the market, but at an average price of 1s. 6d. per lb., the extreme yield per tree varied from 39s. to 3s.

There is another point of practical importance. "It is well known that *Ficus elastica* will grow with undiminished rapidity and luxuriance in situations remote from the hills, but in such localities it fails to yield caoutchouc." Hence, Mr. Mann concludes "that no greater mistake could be made than to start plantations of this tree in the plains of Bengal." This is true also of many parts of the world where the tree has been introduced. In spite of the abundance of the tree under cultivation in the tropics of both the Old and New World, it has nowhere proved so valuable for the pro-

duction of rubber as in the mountainous parts of Assam.

For a time the efforts of the Government of India were suspended. It was felt that no system of inspection could render protection effective over a block of forest of 200 square miles, with perhaps only 10 or 20 trees to the square mile. The illicit tapper works in the rainy season when the forest guards are withdrawn. Further, the northern boundary of the Government abounds in uninhabited and trackless territory except for wild elephant paths, and the rubber once collected could be easily carried across the line, to be re-imported as foreign produce. Mr. H. C. Hill, officiating Inspector-General of Forests in 1896 was, however, strongly of opinion that the plantations of *Ficus elastica* were the only means of assuring a continuous supply of rubber. He pointed out "that the quantity of rubber exported from Assam, annually, at present amounts, in round numbers, to 3,500 maunds, worth, in Calcutta, $3\frac{1}{2}$ lakhs of rupees (£35,000). The Government royalty, at Rs. 12 a maund, amounts to Rs. 42,000 (£4,200) a year. It behoves the Government to invest a fair proportion of these receipts. The only prospect of success seems to be in the direction of artificial plantations, where the trees can be concentrated on a limited area, the effective protection and exploitation of which will be possible."

Mr. Hill continued as follows :—

"In order to ascertain what prospect of yield the plantation gives at present, I had four good trees tapped. Their age is 18 or possibly 20 years, as the old trees date from 1875, and the first compartments were only successfully planted in their present completeness in 1877-8. They yielded respectively 23, 21, 11, and 48 chittacks (approximately equivalent to 3, 3, $1\frac{1}{2}$ and 6 lbs.). This was valued locally at Rs. 97 a maund, and allowing for some further drying and a fair rate for collection, the net value may be taken at Rs. 80 (a little over 1s. per pound). The rubber was sent to Dr. Watt with a view to his obtaining an independent valuation in Calcutta. The result of this valuation is Rs. 105 to Rs. 108, Rs. 100 to Rs. 105, Rs. 110 to Rs. 115, Rs. 110 to 112 respectively, per bazaar maund landed in Calcutta (equivalent to an average price of 1s. 6d. per lb.). One man taps three trees in a day or collects the rubber from two trees, so that 15 men would tap and collect the rubber from an acre containing 18 trees. Allowing a margin, the collection should be done for Rs. 10 a maund. The yield varies with the spread of the crowns and the more or less openness of the situation. The smallest yield was obtained from an enclosed tree in the middle of the compartment: the largest from a tree open on two sides situated on the bank of the Mansiri

river. Previous tapplings had been confined to the least vigorous and most suppressed trees in the lines, and hence the rubber obtained gave no indication of the yield of the plantation, the dominant vigorous trees of which alone yield rubber freely. I think the yield obtained from these few trees justifies the assumption that 20 seers (11 lbs.) could even now be obtained from an acre, and that it is reasonable to suppose a maund will be readily obtained at or before the age of 50 years, and that Rs. 16 per acre per annum can be counted upon. If these views are accepted, there would seem to be a good case for extending the plantation by 250 acres a year, at a cost of Rs. 10,000, for the next 12 years at least. By this time it will cover an area of 5,000 acres, the prospective yield of which would be, even according to Mr. McKee's estimate, 1,000 maunds of rubber per annum, adding a net income of at least Rs. 80,000 to the forest revenues of the province. As already shown, Government is only required to forego 25 per cent. of the revenue it is now deriving from the extermination of the natural rubber trees. Considering that men are ready to pay up to Rs. 38 a maund for rubber collected from the forests in the Tezpur district, with a guaranteed yield of 168 maunds from one of the two mahals (eastern) into which the district has been divided, it may be desirable to raise the royalty from Rs. 12 to Rs. 20 a maund. This would still leave an ample margin for profit since the cost of collection and carriage varies from Rs. 16-8 in the Garo hills to Rs. 30 paid by mahaldars."

Commenting on the decline of the exports of india-rubber from Bengal, the Collector of Sea Customs, Calcutta, stated, in the annual statement of the sea-borne trade and navigation of Bengal, that "it is a pity that something cannot be done to improve the method of collecting Indian caoutchouc, which at present does not command in Europe and America as high prices as that from other countries. It would seem probable that, with proper care and more attention to the extraction of caoutchouc according to methods adopted in the places which supply the best description, the value of the trade to India would materially increase. I understand that the inferiority of the Indian article as exported is not due to the inferiority of the trees in Assam, but to the careless way in which the caoutchouc is collected, and to its coming into the market so full of extraneous matter." This extraneous matter is said to consist of pieces of bark, wood, mud, sand, and stones.

OTHER INDIAN RUBBER PLANTS.

A handsome climbing plant, the "Pulay" (*Cryptostegia grandiflora*), with glossy leaves and pale purple flowers in large terminal clusters, probably a native of Madagascar but

now naturalised in India and many parts of the tropics, is said to yield good rubber.

The Conservator of Forests, Northern Circle, Bombay Presidency, wrote on the 16th Jan., 1888, "*Cryptostegia grandiflora* is cultivated in gardens in nearly every station in India, and can be easily propagated. The cost of collecting the sap would be so great that a plantation is not likely to be commercially successful. The plant grows practically wild in the Western Ghâts." A sample of rubber from Bombay, received at Kew in 1897, was described "as badly prepared and full of sand and other impurities. The quality of the rubber itself was good and if properly prepared and cleaned it would be worth 2s. 6d. per pound or more." It is quite possible that by coppicing the plant and taking yearly crops of shoots this plant might yet be rendered of value.

Alstonia scholaris is a large evergreen tree, 60 feet high, found in the drier forests of India but extending to Ceylon, Singapore and Penang, the Malay archipelago, tropical Australia, and Africa. It has rather large leathery leaves and greenish-white flowers with very long and slender follicles. The milky juice is very bitter. It has long been regarded as producing an inelastic rubber-like substance but so far no use has been found for it.

In 1884 Dr. Ondaatje forwarded from Ceylon a large sheet of a substance obtained from the milk of *Alstonia scholaris*. He described it as a good substitute for gutta-percha, being very plastic, soluble in chloroform, and precipitated by alcohol; also resistant to acids. The substance sent had evidently been prepared with some care and pressed into sheets. No information was given as to the quantity available or the cost of production. The specimen is still in the Kew Museum.

Chonemorpha macrophylla is a stout climbing shrub, found in moist forests throughout India, Ceylon, Malacca, Andaman Islands, Sumatra, and Java. We know little or nothing of the value of this as a rubber plant. Kurz ("Forest Flora," ii., 187) quotes Mr. Parish as saying that "it yields a considerable quantity of caoutchouc."

There are a few other Indian plants yielding milk, containing caoutchouc in a more or less impure state. *Artocarpus Chaplasha*, according to Kurz, "yields a tenacious milky caoutchouc." *A. integrifolia*, the common Jack-fruit tree, is said, by a writer in the *Indian Agriculturist*, to yield "an elastic, leathery, and water-resisting" substance, but Dr. Helfer states, "it does not dry perfectly."

A somewhat similar substance is used in Ceylon and Singapore as a bird-lime. *Ficus laccifera*, according to Gamble, yields "caoutchouc more sparingly than *F. elastica*, and of inferior quality."

Willughbeia edulis, a large climber, with long tendrils, native of India and the Malay archipelago, is sometimes cultivated for the sake of its berry outwardly resembling a mango. The plant yields a pure white viscid juice, which is changed by exposure into an indifferent kind of india-rubber. *W. zeylanica* of Ceylon, with a large handsome fruit—a favourite food of monkeys—yields "a putty-like substance, with scarcely any elasticity."

UPPER BURMAH OR RANGOON RUBBER.

This, for the most part, is also produced by *Ficus elastica*, of which whole forests exist in certain parts of Upper Burmah. India-rubber was first exported from this region to Rangoon in 1870. It is carried down the Irrawaddy. Up to 1873 the trade was free to all who chose to engage in it, but since that time the forests have been worked by Chinese under a monopoly from the Burmese Government. The price paid was about Rs. 70,000 per annum. According to Mr. Warry, "the Chinese say that the india-rubber tree occurs throughout a very extensive district stretching several hundred miles north of Mogaung, and extending to the east far across the Chinese border. A fractional part only of this immense area has been worked." The tapping is almost entirely in the hands of the Kachins, who are very jealous of interference with the trees and careful in their methods of tapping them. In three years, it was estimated by Mr. Warry that about 200 tons of rubber were sent from Bhamo to Rangoon by the Chinese monopolists, and that they cleared 17 per cent. on the capital invested.

In August, 1892, the following rule was issued for regulating the tapping of india-rubber trees in the Bhamo and Upper Chindwin districts of Burmah:—"Trees may be tapped only during the months of December, January, February, and March. Stems on aerial roots measuring less than 3 feet in girth at 3 feet above the ground, as well as the underground roots of trees and the lowest part of the stem within 3 feet from the ground, may not be tapped, and no india-rubber trees may be felled, burnt, or tapped. The incisions must not exceed 1 foot in length and 4 inches in breadth."

The following Table illustrates the relative share taken by Assam and Burmah in the exports of rubber from India, for the years 1887 to 1892 inclusive:—

Year.	Bengal.		Burma.	
	Cwt.	Rs.	Cwt.	Rs.
1887-88	6,251	6,97,654	2,977	4,56,681
1888-89	5,609	6,09,195	3,054	3,58,153
1889-90	4,511	5,34,584	5,423	6,02,914
1890-91	4,185	5,15,986	5,107	6,57,189
1891-92	3,563	4,60,786	5,771	7,11,584

The receipts of Bengal (Assam) india-rubber in the United Kingdom in 1896 was 100 tons, of the value of £16,309, and of Burma (Rangoon) rubber 228 tons of the value of £46,307.

There are probably other sources of india-rubber in Burmah, but the exact extent of their production is not known. One promising species appears to be *Urceola* (Chavannesia) *esculenta*, Benth., a climbing plant with smooth branches and leaves, known locally as "Kyat-poung-hpo." This is stated by Strettell to be a troublesome weed in the teak forests of Burmah, but yields caoutchouc of excellent quality. The plant is cultivated to some extent for the sake of its fruit, which finds a market as a substitute for tamarinds. It has been under experimental cultivation in Madras but it was found to be slow of growth, and not regarded as of much promise as a rubber producer.

PENANG AND SINGAPORE RUBBER.

Possibly the best rubber plant of the Malay peninsula is *Willughbeia firma*, Bl., known as "Gegrip hitam" and "Gegrip besi," a large climber with black bark, hence its name. According to Murton, quoted in "Kew Report," 1880, p. 46, the rubber agrees "very closely in texture, appearance and mode of preparation with the "gutta-susu" of Borneo. It is the produce of a large woody climber with stems about six or eight inches in diameter, of which there are two varieties, one with outer bark very dark, with lighter coloured warts and inner bark red, the other has the outer bark light cork coloured, and with longitudinal channels, and the inner bark light yellow. Both yield edible fruits, of which the Malays are very fond, that of one being pomiform and the other pyriform. The foliage of both is very much alike. The gutta from the dark barked variety is considered the best."

Mr. Murton thus describes the mode of collection:—

"The stem is ringed at intervals of 10 to 12 inches, and the milk allowed to run into vessels made of palm or other leaves, cocoanut shells, or anything available for the purpose; it continues to flow for some time, but after flowing for ten minutes it becomes watery and thin. One plant will yield from five to ten cattiees of the coagulated caoutchouc. When raw it has the appearance of sour milk, and to coagulate it the natives add salt or salt water; when freshly coagulated it is quite white, which gradually changes to a darker colour. It keeps white inside, and on cutting, it presents a foveated appearance, the cells containing water and salt, which have become enclosed during coagulation. In texture it is soft, very spongy, and very wet."

Willughbeia flavescens is mentioned in the "Kew Report," 1880, p. 47, under the name of *Chilocarpus flavescens*, as a rubber plant of the Malay peninsula. Mr. Murton sent specimens to Kew, together with the wood and gutta prepared in the usual way. On the latter, Messrs. Silver reported, "the quality of this rubber is very fair, and it would be useful in our manufacture. The present value (in 1879) is about 1s. 3d. per lb."

W. coriacea, a lofty jungle climber, known in Malacca as "Gutta Menjawa," and *Melodinus orientalis* yield rubber that sets very slowly. It is used only for mixing with other rubbers.

Leuconotis eugenifolius is a milky ever-green shrub, with a smooth bark, found at Penang in the Malay peninsula, and extending to Sumatra and Borneo. The leaves are dark brown above, "paler beneath, yellow brown and minutely dotted, and with strong horizontal nerves." The fruit is described as "the size of a gooseberry." This plant probably yields some of the rubber from the Straits Settlements, and where it is known, according to Mr. Ridley, as "Gegrip Sundik."

Judging by the character of Malay rubber, as received in this country, there is little doubt that some of it is obtained from *Ficus elastica*. The commercial article is known locally as "Gutta Rambong." The tree is apparently found in the interior forests in districts visited only by the natives.

A tree known as "Gutta telutong," is probably *Dyera costulata*, with stout branches, hard, shining, leathery leaves and foliicles, about a foot long, covered with rusty scales. The milky juice is said to be used to mix with that obtained from the species of *Willughbeia* already mentioned. *D. Maingayi*, also known

as "Gutta telutong" yields an inferior india-rubber, while *Artocarpus Kunstleri*, "Gutta Terap" produces a kind of rubber (or rather a bird-lime) used only for catching birds.

Singapore has for a long period acted as the *entrepôt* for rubbers from all parts of the Malay archipelago from the Malay peninsula, Sumatra, Java, Manila, Borneo, and possibly New Guinea. The quantity shipped to Europe has varied considerably. During the year 1896 the rubbers received from the Straits Settlements (Penang and Singapore) into the United Kingdom amounted to 830 tons, of the value of £117,155.

According to Mr. Curtis "what is sold in London and elsewhere as Penang rubber comes from Sumatra and Perak, the greater proportion being from the former country. A portion of the 'Gutta Rambong' that comes from Sumatra is from cultivated trees, but the Perak portion is entirely from wild trees in the interior. In my journeys in Perak I have never come across a tree, so that I do not think it occurs anywhere near the coast. The people here who buy the rubber at first hand are the Chinese, who either sell to the principal European merchants, or hand it over to them to sell in London on their account. As soon as it arrives in Penang it is stored in huge wooden vats, filled with water, and kept there until there is an opportunity of shipping it. It absorbs water to the extent of about 20 per cent. of its weight."

The exports for last year from Penang were, "Gutta Rambong" (*Ficus elastica*) 4,650 piculs; "Gutta-susu" (*Willughbeia*) 830 piculs.

SUMATRA AND JAVA RUBBER.

In the learned "Monograph of the Species of *Ficus*," by Sir George King, vol. i., p. 45, he describes *Ficus elastica* as a large tree, usually epiphytic. In regard to its occurrence in Java he supplies the following interesting information:—

"This species was originally named *elastica* by Roxburgh, and plants under this name were sent to Java, where however the plant is indigenous, and is known to the natives as *Karet*—a name subsequently utilised as a specific name by Miquel. Blume published a description of the plant, under Roxburgh's name in his "Bijdragen," which appeared seven years before Roxburgh's "Flora Indica" was published; the death of this able botanist having caused the publication of his "Flora Indica" to be delayed until 1832."

A sample of rubber in the Kew Museum,

marked "Getah Karet," from Sumatra, is very similar in appearance to Assam rubber; so also is a sample marked "Getah Achin," sent by Wilson, presumably obtained from north-west Sumatra. The inference is that these rubbers, as well as a similar substance obtained from Java, with a firm texture, mottled appearance, and bright, polished surface, are obtained from *Ficus elastica*. De Vrij states that this tree is known in Java as "Pohon Karet." According to Collins, the natives incise the tree and allow the milk to dry *in situ*. The strings thus obtained are made into a rope-like torch, and used in searching for edible birds' nests. The quantity of rubber obtained from these sources is evidently very small. Very little comes direct to this country.

That *Ficus elastica* yields the "Karet" rubber of West Java is confirmed by the high authority of Dr. Treub, who adds, "it is possible that in some parts of the island other species of *Ficus* are also tapped for rubber." An investigation of the rubber plants of the Malay archipelago will probably be undertaken shortly, at the instance of the Government of the Dutch East Indies, by Dr. von Romburgh.

The exports of india-rubber from Oleh-leh (Sumatra) during 1882 reached 1,710 lbs., and according to Mr. Consul Kennedy's report, dated February 9th, 1883, they were chiefly from the north and west coasts, and it is evident that the high prices for this article prevailing in Europe have somewhat stimulated the search for it in Sumatra.

The following were the exports of rubber from Padang and Sumatra during the years named:—1885, 631 piculs; 1886, 4 piculs; 1887, 104 piculs; 1888, 1,086 piculs; 1889, 455 piculs; 1890 (exports to the United States only), 422 piculs.

A later report (1897) states:—"Numerous india-rubber trees are growing on the east coast of Sumatra in a wild state, and the natives have collected large quantities of rubber, to the great damage of the rubber-tree, which have become debilitated and, in some cases, extinct. Within the past few years wealthy Holland companies have created rubber plantations, and in the Kassan district a not unimportant market in Sumatra rubber may be expected in the near future."

An interesting experiment in the cultivation of the Karet tree (*Ficus elastica*) as a source of india-rubber was started in the province of Kranog in Java in 1872. The first notice of

this was given in the "Tijdschrift van Nijverheid en Landbouw," published at Batavia in 1885. Recently, May, 1898, A. H. Berkhout (late Conservator of Forest in Java), contributed the following results, to the end of 1895, to the "Indian Forester," vol. xxiv., pp. 160-161. :—

"A former proprietor of the Pamanockan Tjiassan Estate which is the largest private property in Java, containing 540,000 Dutch acres, had most of his land under coffee until 1872. Finding the cultivation of this plant was no longer lucrative, he planted some of the land up with *Ficus elastica*. The coffee plantations had already been more or less cleared of forest growth, so that the planting of *Ficus elastica* cost less than thirty shillings per acre. The soil of these coffee gardens had become useless for other agricultural purposes; and had not *Ficus elastica* (Karet) been planted in time, would only have become covered with poor forest growth. The trees were planted $8\frac{1}{4}$ yards apart, or 72 trees to the acre. The area planted was $7\frac{1}{2}$ acres, containing 5,200 stems. The trees were first tapped when the plantation was 14 years old, and the yield for that and the six following years was :—

Year.	lb.	Average oz. per stem.	Value. £
1886.....	5,512	17	600
1887.....	4,954	15	540
1888.....	1,514	4	165
1890.....	3,307	10	360
1891.....	6,113	18	387
1892.....	5,992	18	256
1895.....	3,197	10	411
Total....	30,589	Average per year per stem 6 oz.	2,719

$7\frac{1}{2}$ acres thus, it is said, yielded in seven years a supply of £2,719, or per acre per annum £5 8s. The yield was 71 lbs. per acre per annum during this period. During the 23 years from the establishment of the plantation in 1872 till 1895 the net yield per acre per annum amounted to £1 12s. 10d.

It will be noticed that the largest yield of rubber was obtained when the trees were first tapped at 14 years old in 1886. Since then the net returns have fluctuated, in some years very considerably, but on the whole they must be regarded as distinctly encouraging. Once the trees are established the only expense is the cost of tapping and collecting the rubber. In the case of *Ficus elastica* the rubber coagulates on the trees without preparation. It is to be observed that if Para rubber or *Castilloa elastica* trees had been planted on favourable situations in the same province the results might have been still more satisfactory.

PHILIPPINE ISLANDS.

So far it would appear that little or no rubber comes from the Philippine Islands.

Chapel mentions a creeper called "Bolo," as a rubber-yielding plant, but Mr. Rolfe who has studied the Philippine flora is unable to trace this plant. There is also mention of the "Baleté," *Ficus indica*. Of plants belonging to the natural order Apocynaceæ there are 16 genera represented in the group, and amongst them are *Alstonia macrophylla*, *A. scholaris*, and *Parameria philippinensis*. There is, however, no indication that any of these produce rubber.

COCHIN CHINA.

Some of the climbing plants mentioned as yielding rubber in the Malay peninsula extend to the eastward to Siam, Cambodia, and Cochin China. One of the most prominent of these, the plant known in Burma as "Talineno-thee," is *Parameria glandulifera*. This plant, prominently mentioned some years ago, has a wide distribution in the Eastern tropics. It is found at Martaban in British Burma, on the borders of tidal forests, in Malacca and Singapore, the Andaman Islands, Java, Borneo, Philippine Islands, and Cambodia in Lower Cochin China. It is a stout climber, with smooth leaves and a large panicle of small sub-campanulate flowers. The follicles (fruit) resemble those of *Urceola*.

According to M. Pierre (who first drew attention to the economic value of the plant in Saigon), the method of extracting the caoutchouc is exceedingly simple. The milk obtained either from incisions or by cutting the stem into short lengths is poured into a basin filled with water at a temperature of 104° - 122° Fahr. On agitating the mixture with a stick, the milk immediately coagulates into a pure caoutchouc of excellent quality. The plant may be propagated by cuttings with great facility. Dr. Trimen, in 1884, supplied the following further information on the subject :—

"The attention of the Indian Government was called to this rubber plant in 1883 by the Deputy-Commissioner of Mergui, British Burma, the 'Talaing Milk Creeper' of that district, according to Dr. King's identification of very inadequate specimens, being the same species. The reports as to its yield there are somewhat conflicting: the Deputy-Commissioner states that he obtained about half pound of rubber from a piece of stem 80 feet long and $8\frac{1}{2}$ inches circumference by extracting all its juice, but, according to the Director of Agriculture of British Burma, this is not a fair estimate, as 'a bottle full of the milk' was obtained from 'a few feet of the creeper.' Dr. Romanis, chemical examiner, states that 'one pint of juice yielded $13\frac{1}{2}$ oz. of caoutchouc,' which appears a very high proportion. The specimen of rubber re-

ceived by Dr. King he describes as 'externally considerably discoloured and almost black from being partially oxidised. When cut into it is white and porous, presenting a honeycombed appearance, the spaces containing a dirty-brown watery fluid. It is tough and elastic, and appears to be of excellent quality.'

CHINA.

In a Foreign-office Report on the trade of Tamsui (Formosa), for the year 1890, Mr. Consul Holland states:—

"I have great hopes that there may be a new opening for British trade in connection with india-rubber, as there seems to be no doubt that the tree exists here, though no one knows much about it. I am in communication with an English expert on the subject, who I hope will either come himself, or send a skilled *employé* to show the natives how to tap the trees."

Nothing appears to have resulted from this action. Probably some species of *Ficus* exist in the tropical parts of China, but the only plant of which we have actual information as containing rubber is the following.*

Tu-chung (*Eucommia ulmoides*) is a native of Central China, where according to Dr. Henry it is cultivated in the districts of Changyang and Patung in Hupeh, N. lat. 35°. It is also, according to Farges, cultivated in about the same latitude in Eastern Sze-chuen in the district of Tchen-keou-tin. As Professor Oliver points out, a singular feature about this plant is the extraordinary abundance of an elastic gum in all the younger tissues, especially in the bark, the leaves, and petioles. Any of these snapped across when dry, and the parts drawn asunder, exhibit the silvery sheen of innumerable threads of this gum. The bark itself, to which, according to Dr. Henry, tonic, invigorating, and anthritic properties are ascribed, is a most valued medicine with the Chinese, selling at 4s. to 8s. per lb. Further, the leaves are eaten when young, and the fruit is astringent.

The merits of the Tu-chung as a caoutchouc-producing plant are entirely unknown. It is, however, deserving of notice. It would be likely to thrive in semi-tropical countries, such as Algeria and Florida, and in the mountainous parts of Southern India and the West Indies. It might also survive the winters of Southern Europe.

BORNEO RUBBER.

The earliest notice of Borneo rubber is said

to date from 1798. It was not until about forty years ago that it first was known in English commerce. It was at first called "Gutta Susu," the Malay name for milk-gum. Sir Hugh Low ("Sarawak," 1848, p. 52) referred to Borneo rubber as follows:—"The natives of Borneo use it to cover the sticks with which they beat their gongs and other instruments. The fruit, which is large and of a fine apricot colour, contains ten or twelve seeds enveloped in a rich reddish pulp, and though a jungle plant, is one of the most grateful fruits of the country to the European palate." This fruit was doubtless that of a species of *Willughbeia*, not of a *Urceola*.

In Hooker's "Journal of Botany," v. p. 158, the following further information is given:—"This gum, the produce of creepers known in North-west Borneo under the names of 'Serapit,' 'Petaboo,' and 'Menungan,' is the milk-like sap of these creepers, which, by the addition of a little salt water, takes the consistency and all the peculiarities of india-rubber, being at first snow white, but by exposure to the air changing slowly to a dirty yellow, and afterwards to a brown colour. The 'Serapit' produces the most common, the 'Petaboo' the best, and the 'Menungan' the greatest amount of sap. The gum obtained in this way contains water, enclosed in small cavities, formed by the celerity with which the sap hardens, preventing thereby the salt water and, perhaps, the watery part of the sap from finding an issue."

In the British North Borneo Handbook (1890, p. 78) it is stated:—"India-rubber is the sap of a creeper of the genus *Willughbeia*, which attains some three or four inches in diameter. It occurs very generally all over the country, but is not particularly plentiful in any one district. It grows under natural forest shade and requires only about four years to come to maturity. From the almost complete absence of expense attending its cultivation it might well receive systematic attention both from Europeans and natives; the latter have already made some progress in this direction. In four or five years' time every creeper should give two or three dollars worth of 'Gutta susu.' The price usually obtained by collectors is from 30 dollars to 40 dollars per picul."

An investigation of the rubber-yielding plants of Borneo, based on the collections made by the late Mr. H. J. Murton, of Singapore, Mr. F. W. Burbidge, F.L.S., who travelled in Borneo in 1878, and Mr. W. H. Treacher, C.M.G., the Colonial Secretary of Labuan,

* See Oliver in Hooker's "Icones Plantarum" tt. 1950 and 2361; Weiss in "Transactions Linnean Society" (Botany), vol. iii. [2], pp. 243-253, tt. lvii. and lviii.

was made by Mr. W. T. Thiselton Dyer, C.M.G., F.R.S., in 1880. The most authentic information on the subject was published by Mr. Treacher in the "Journal" of the Straits Branch of the Royal Asiatic Society for July, 1879 (p. 58). There are there enumerated no less than eight rubber-yielding plants. Those yielding good qualities of "Gutta-lechak" or "Gutta-susu" are four in number, as follows:—

1. "Manungan pulau" (Manungan proper).
2. "Manungan bujok."
3. "Manungan manga" (light coloured bark).
4. "Manungan manga" (dark coloured bark).

Mr. Treacher remarks that the different plants are accurately distinguished by native collectors. All the species enumerated above have axillary, not terminal, flowers, and, as mentioned by Sir Hugh Low, the fruit is edible. They differ in the shape of the leaves and fruit, and in the corrugations of the bark. Mr. Thiselton Dyer was disposed to refer them all to the nearly related genera *Willughbeia* and *Leuconotis*, which in Malaya represent the allied *Landolphia* of tropical Africa, with the same tall, climbing habit, and woody cable-like stems.

1. "Manungan pulau" has been identified as *Willughbeia firma*, already mentioned as yielding some of the best rubber in the Malay peninsula and Sumatra. This is a jungle climber with stout branches, obtusely angled, and a smooth bark; leaves variable, very coriaceous, with a stout midrib beneath; flowers small, $\frac{1}{4}$ inch long, in very compact cymes; fruit as large as, and the form of, a good sized pear, 4 inches long, orange yellow; seeds 1 inch long.

2. "Manungan bujok," with egg-shaped fruit, may be *Leuconotis eugenifolius*. According to Mr. Burbidge, "this yields the best gutta of the Bornean woods."

3. "Manungan manga," with a light corky bark and round fruits, rarely exceeding two inches in diameter, may be a *Willughbeia*. Its corky bark and small fruit distinguish it from other Bornean caoutchouc-yielding plants, but it is said "to yield very good gutta." According to the "Kew Report" (1880, p. 45), the information received at Kew disposed of a rather serious blunder which has crept into most books on economic botany. Collins, in 1872 ("Caoutchouc," p. 24), identified Bornean rubber known as "Gutta-susu" as the produce of *Urceola elastica*. This was incorrect. *Urceola elastica*, instead of having a large,

sound, edible, apricot-coloured fruit as first described, has dry elongated pods. The error made by Collins is followed in the article on india-rubber in the "Encyclopædia Britannica" (9th ed.), xii. p. 839, where it is stated "the plant which yields Borneo rubber was identified by Roxburgh as *Urceola elastica*, Roxb., an Apocynaceous climbing plant with a trunk as thick as a man's body and having a soft, thick bark." Dr. Stapf, the Assistant for India in the Kew Herbarium, writes:—"There is no evidence that *Urceola elastica* has been found in a wild state in Borneo, nor can I find a passage in Roxburgh's publications referring to the occurrence of *Urceola elastica* in that island." It is evident, therefore, according to the most recent information, that none of the Bornean rubber is derived from this plant. All the information available points to the conclusion that the plants are species of *Willughbeia* and *Leuconotis*.

"Borneo rubber comes into the English market in the form of balls or shapeless masses internally of a white or pinkish colour and very porous and spongy, the pores being filled (as described above) with salt water, in consequence of which it often loses 20 to 50 per cent. of its weight in drying. . . . The rubber is obtained by cutting the plant into pieces varying from a few inches to two or three feet long, and allowing the juice to drain into buckets or jars, heat being sometimes applied to one end of the pieces when the juice flows slowly." The milk is coagulated by salt water prepared from the ash of the leaves of the Nipa palm. The balls of rubber for convenience of carrying are threaded on a strip of rattan. The exports in 1885 were 116,480 lbs., of the value of £5,827; in 1886, 147,840 lbs. of the value of £7,355. Last year (1897) they were 768,320 lbs., of the value of about £70,000. The price (in July, 1898) was 1s. 4d. to 2s. 2d. per lb. A peculiar rubber stripped from Pontianac on the equator in West Borneo, is a soft white inert substance, almost devoid of elasticity and evidently now used only to a small extent. The imports in 1895 were 306,880 lbs., in 1896 they had fallen to 40,320, while in 1897 they were only 11,220 lbs.

NEW GUINEA RUBBER.

This is one of the latest additions to the list of Asiatic rubbers. The plants, so far, appear not to have been determined. Sir William Macgregor, in a recent report on the products of British New Guinea, speaks of rubber from

that dependency as follows:—"Taking into consideration the fact that this product is obtained from several indigenous trees and plants, that it exists over a great area, and that there is a large extent of country eminently suitable for the cultivation of rubber trees, it seems very probable that this may eventually become the principal export from the possession."

In a report issued by the Colonial-office (No. 8, 1897), the British Resident in the Solomon Islands mentions that "one of the Aola traders who had just returned from British New Guinea, had shown him some samples of rubber now being procured there by the natives. The man stated that he had seen the same tree as that from which the samples were produced growing in the Solomon Islands, and from his description it appeared to be a species of *Ficus*. The natives of New Guinea, according to this trader, allowed the sap to run over their arms and body, and when it was sufficiently hardened they removed it and rolled it up into lumps. The lumps were rather larger than a cricket ball. The rubber was said to be worth to the New Guinea traders 2s. 6d. to 3s. per lb."

It is elsewhere stated that both trees and vines yield rubber in British New Guinea. The exports in 1896-97 were estimated at 67,000lbs., of the value of £7,000. The price quoted in London (July 1, 1898) was 2s. 8d. to 2s. 10½d. per lb.

Fiji RUBBER.

There are one or two promising india-rubber plants in the Fiji Islands, but the natives are evidently not enterprising enough at present to thoroughly utilise them. Mr. John Horne, F.L.S., late Director of the Botanic Gardens at Mauritius, has given ("Year in Fiji," London: Stanford, 1881) the most connected account of the rubber plants of this group. *Tabernaemontana Thurstoni* (named in honour of the late governor) is spoken of as "decidedly our best rubber plant." The tree grows to a large size, up to 18 inches or 2 feet in diameter. It is found scattered in the forest, on both hills and valleys, but is not gregarious. According to the *Kew Bulletin*, 1889, pp. 164-166, a specimen of rubber from this tree, recently received from Fiji, was hard and gutta-like, and without elasticity, probably due to defective preparation.

Another plant, mentioned by Mr. Horne, is *Alstonia plumosa*. Of this there is a hairy form, with smaller leaves (*A. villosa*, See-

mann). The large-leaved plant is known locally as "Drega quruquru." To obtain the juice, the Fijians break off the leaves from the branches, and collect it in their mouths; this makes the caoutchouc as adhesive as glue, and of about the consistency and colour of putty. The branches are next removed, and each is broken into pieces from 6 to 10 inches long. Mr. Horne continues:—

"As fast as the pieces are broken, first one end of them is placed in the mouth, then the other, till the mouth is full of crude caoutchouc. Several mouthfuls are collected together and squeezed into a round mass or ball. This method of collecting the juice, with the ruthless manner of breaking the trees, somewhat surprised me when I first saw it done. Since then repeated trials in all parts of Fiji have convinced me that the sap or juice does not flow freely by wounding the bark on the trunk of the tree in any way whatever. This is the reason for breaking the branches. The youngest branches of the tree contain most juice. When the old or firm-wooded branches are broken very little sap flows from them. When the young branches are broken the sap flows rapidly for a few seconds. It soon coagulates when exposed to the air, and the wound has to be freshened to cause the sap to flow anew. When the branches are broken into pieces of about a foot in length the juice flows from the ends, and the pieces are drained almost entirely. A little more may be obtained by breaking the pieces in the middle, but very little. The juice flows from between the bark and the wood, and from the pith, or from between the pith and the wood.

"The coagulated juice would seem to have some attraction for the juice in a semi-liquid condition. If a portion of the coagulated juice be applied to the semi-liquid juice adhering to the ends of a broken branch, the slightest touch makes them join firmly. The adhesion is so perfect that the portions will not be separated, and a slight pull takes the semi-coagulated juice clean out of the many fissures or cracks in the ends of the broken branch. To obtain crude caoutchouc from this tree the juice has simply to be collected and worked with the fingers. It requires no other preparation. The juice congeals so rapidly that when collected in dry weather it requires little, if any, drying. The caoutchouc may be sent to market in balls, or it may be pressed in moulds into long thin pieces, one or two inches broad and an inch in thickness (more or less), as may be required. Samples of it have been sent to England, and the quality was highly valued."

Alstonia plumosa is known in Viti Levu as "Sarua." It is described as abounding in the forests, and if carefully treated, might prove a useful rubber-producing plant. Mr. Joske, the Commissioner for Colo North, states "the leaves are large and glossy: the gum is obtained from the petiole or stalk. As soon as the leaf is broken a thick milky juice

exudes, which when exposed to the heat of the sun for a little while congeals. It is then detached with a bit of bamboo or knife and the different particles are pressed together into balls. That is the way it is produced when required as an article of commerce."

Of plants not noticed by Mr. Horne there is a tree known as "Baka" (*Ficus obliqua*, Forst. f.). According to Mr. Joske, this "yields quantities of rubber." Further, "it is used by the natives of the interior as birdlime with which at certain seasons of the year they catch wild pigeons; it is very easily procured. Incisions are made in the bark and underneath are placed bamboos which receive the sap as it pours out. It is coagulated by means of heat, . . . the natives say they could get immense quantities of this without much trouble. Were it discovered that the rubber was of commercial value it would prove an estimable boon to the natives of these islands."

Although the specimens of "Baka" rubber received at Kew had not been sufficiently coagulated, it was regarded by Messrs. Hecht, Levis, and Kahn as suitable for mixing purposes, and its value (1898) was placed at 1s. to 1s. 3d. per lb.

If none of the native plants can be turned to account, the soil and climate of the Fiji Islands should afford favourable conditions for the cultivation of either Para or Central American rubber. On lands now planted with bananas the Ule (*Castilloa elastica*) would be likely to prove a most suitable plant. Seed might be obtained from Panama, or the Pacific slopes of Mexico.

CULTIVATION OF RUBBER TREES.

In view of the possible falling off in the supply of commercial india-rubber, it has often been suggested that efforts should be made in the countries where the trees are found wild, to replant exhausted areas.

In the State of Amazonas in Brazil, the Government has endeavoured to regulate the tapping of the trees, and, at the same time, to encourage the re-planting in districts where the trees are becoming scarcer. So far, however, little has been really accomplished. It is possible that such efforts will be revived in connection with the rubber companies lately started in Brazil with British capital.

Plantations of *Manihot* are being started at Mt. Alegre in the State of Ceara.

According to a Report prepared by the American Consul in 1890, "practical experiments with the cultivation of rubber trees have

been made in Mexico by various intelligent persons in different parts of the country, notably in the district of Soconusco, the State of Chiapas, and the State of Vera Cruz." These experiments are said to have shown that the "industry can be established with entire success." It is stated that 160 acres planted with 10,000 trees, 23 feet apart, in the sixth year yielded at the rate of 2½ lbs. per tree, worth \$3,920. At the end of the sixth year, after paying all expenses, the net profit was estimated to be \$4,234; at the end of the seventh year it was estimated at \$7,128, and increasing steadily for a number of years.

The Government of Nicaragua has issued a decree giving a premium of 10 cents for every rubber tree planted where the number does not go below 250 planted by any one person. The decree provides that the trees must be planted 16 feet apart.

My observations in British Honduras have led me to the conclusion that, planted in suitable localities and well cultivated, *Castilloa* trees, used as shade trees for coffee and fruit trees, and planted 40 feet apart, would yield a gross return at the end of eight or ten years of about £1 per tree, or at the rate of £25 per acre. If, on the other hand, the trees are established by themselves in regular plantations at 20 feet apart, the gross return at the end of eight or ten years would be probably double the above amount.

Near Guayaquil, in Ecuador, 20,000 trees were planted in 1884. The yield per tree was estimated at 3 lbs., or 600 lbs. per acre. At 1s. 6d. per lb., this would give a gross return of £45 per acre.

According to the United States Consul at Columbia in 1890, the Panama Plantation Company had established a small plantation near Colon in 1889. At the end of the first year only 5 per cent. were lost in transplanting out 20,000 trees. The annual cost of weeding, &c., was placed at \$2,000, until they were large enough to be tapped. The annual net return per acre in full bearing was estimated at \$150.

African rubber plants—As already stated the climbing habit of the india-rubber plants of East and West Africa renders them unsuitable for cultivation in regular plantations. A suggestion has been made to coppice them and obtain a yearly crop of shoots, but nothing has been tried in this direction. They should, however, be carefully protected in their present localities. This is being done in German East Africa. The Administrators there, as already mentioned, have divided "the rubber-producing tracts into four areas, two of which are closed

for three years at a time in order to allow the vines to grow."

It is very desirable that other parts of Africa should be treated on similar lines. In concessions granted in British possessions it is, I believe, in contemplation, to require that a certain number of trees should be planted every year in order to maintain the productiveness of the forests and prevent the plant from being exterminated.

In the case of the rubber trees, such as *Kickxia*, the cultivation could be easily undertaken, and the prospects are distinctly promising.

Native rubber plants of Asia—These, with the exception of *Ficus elastica*, do not offer favourable conditions for systematic cultivation. The Assam and Java rubber trees are being cultivated to some extent. The experiments conducted by the Government of India are the most interesting of any in this part of the world, and deserve to be followed in all localities where *Ficus elastica* is indigenous.

The rubber trees that offer the best inducements for being regularly cultivated in other than their native countries, arranged in the order of their value, from a cultural point of view, are as follows:—

1. Para rubber (*Hevea brasiliensis*).
2. Castilloa or Central American rubber trees (*Castilloa elastica*).
3. *Kickxia africana*.
4. Ceara rubber (*Manihot Glaziovii*).

Three of these are New World plants, and one only (*Kickxia*) belongs to the Old World.

All these plants are readily propagated from seeds and cuttings. These are available in large quantities in their natural habitat, and the plants lend themselves readily to the exigencies of cultivation.

Para rubber trees require a thoroughly hot and moist climate, and a deep rich soil. The mean annual temperature should be about 80° Fahr. It is not necessary that the situation should be swampy. In fact, such situations have been found unsuitable in Ceylon, especially for young plants.

The yield in Ceylon, after nearly 20 years' experience, has been estimated as follows:—
"If the cultivation is taken up in favourable localities, a yield of 120 to 140 lbs. of rubber per acre may be expected after the tenth year."
This would give a return of say 20 per cent. on the capital invested.

In the Straits Settlements, trees six years old, yielded on an average 10 ounces of dry

rubber. If such trees were planted 12 feet apart (300 to the acre), this would be equivalent to a return of 188 lbs. per acre, or of more than 30 per cent. on the capital invested. Possibly 12 feet apart may be too close.

Castilloa trees have not succeeded on a large scale so far in any part of the Old World. They are, however, worthy of further trial. In some parts of the West Indies, especially at Trinidad, these trees are regarded as most promising.

Trees at seven or eight years are expected to yield from one to two pounds of rubber. The milk flows freely, gives 25 per cent. of its weight in pure rubber, is readily separable by mechanical treatment, while the rubber is of excellent quality, almost as good as Para rubber.

Kickxia rubber trees grow very vigorously, probably more vigorously than any other rubber trees. There is no data available as to the age when they yield marketable rubber, but the indications are that they do this at eight to ten years. In West Africa, on the coast lands, this tree should be adopted in preference to any of the American trees.

Ceara rubber trees.—The cultivation of these trees was carried on with great energy in Ceylon a few years ago, but the yield was disappointing. The utmost profit realised was about Rs. 50 per acre at the end of six years.

It may be naturally expected that rubber trees will yield larger and intrinsically better qualities of rubber than wild trees. Also the produce, by the greater care and attention paid to it, will be of higher merit and more uniform in character. The increased value from these causes may be estimated at about 25 per cent.

The lecturer desires to express his warmest thanks to S. W. Silver, Esq., F.L.S., and the Directors of the India Rubber, Gutta Percha, and Telegraph Works Company, Limited, for the loan of valuable specimens of raw and manufactured rubber. He is also indebted to Messrs. Hecht, Levis and Kahn, to Messrs. S. Figgis and Co., and to Messrs. Lewis and Peat, for very interesting specimens of rubbers. These specimens, it may be mentioned, have since been placed in the Museum of Economic Botany at Kew, where they are accessible to all interested in the rubber industry. At Kew also may be seen living specimens of nearly all the species mentioned in these lectures. To Dr. Eugene Obach the lecturer is indebted for the illustration of the implements used in the preparation of Para rubber, and to the Director of the Royal Gardens at Kew, and his colleagues, the officers of that establishment, the lecturer tenders his best thanks for valuable assistance which has, at all times, been most readily given.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.**EXAMINATIONS, 1899.**

The dates fixed for the Society's Examinations in 1899 are Monday, March 13th, Tuesday, 14th, Wednesday, 15th, and Thursday, 16th.

The Programme of Examinations is now ready. Copies of the Programme, with full details, and an Appendix containing last year's questions and reports by the Examiners, can be had, price 3d., post free, on application to the Secretary, Sir Henry Trueman Wood, Society of Arts, Adelphi, W.C.

"OWEN JONES" PRIZE.

This competition was instituted, in 1878, by the Council of the Society of Arts, as trustees of the sum of £400, presented to them by the Owen Jones Memorial Committee, being the balance of subscriptions to that fund, upon condition of their expending the interest thereof in prizes to "Students of the School of Art who, in annual competition, produce the best designs for Household Furniture, Carpets, Wall-papers and Hangings, Damask, Chintzes, &c., regulated by the principles laid down by Owen Jones." The prizes are awarded on the results of the annual competition of the Science and Art Department.

Six prizes were offered for competition in the present year, each prize consisting of a bound copy of Owen Jones's "Principles of Design," and a Bronze Medal.

The following is a list of the successful candidates:—

Brady, Emmet, School of Art, Glasgow—Design for wall-paper.

Brown, William F. G., School of Art, Glasgow—Design for printed velvet.

Grimstone, James, School of Art, Glasgow—Designs for wall-paper.

Hedgland, Ethel, School of Art, Dover—Designs for parasol cover and zouave jacket in cut linen.

Joyce, Florence S. K., School of Art, Birmingham—Modelled design for a finger-plate.

Kiefer, Fred. Charles, School of Art, Battersea—Designs for printed muslin.

The next award will be made in 1899, when six prizes will be offered for competition.

DETERIORATION OF PAPER.

The Report of the Committee of the Society of Arts on the Deterioration of Paper has now been published, price 1s., and can be obtained on application to the Secretary, Society of Arts, John-street, Adelphi, W.C. Two Appendices are printed with the Report:—1. Abstracts of Papers on German Official Tests, 1885-96; 2. Précis of Correspondence.

Proceedings of the Society.**CANTOR LECTURES.****DECORATIVE BOOKBINDING.**

BY CYRIL DAVENPORT.

Lecture I.—Delivered January 24, 1898.

ARCHAIC AND MEDIEVAL BOOKBINDINGS, UP TO THE 15TH CENTURY.

The covers, boxes or bindings, in which manuscripts or printed books have been preserved have, as a general rule, had some analogy in outward form to the inner shapes of the written or printed pages they cover.

After the rock inscriptions, which from their nature required no covering, probably came something resembling the impressed inscriptions in clay which still exist. The rock inscriptions were marked in outline on the stone by scribes or priests, and actually cut by workmen ignorant of the sense of the characters they were producing. In the case of the cuneiform inscriptions cut in stone, they were most likely written out by the wise men by means of short and long lines differently placed, the stone-cutter producing the wedge-shaped form. In a country, however, where the use of sun-dried clay was well understood, it may easily be imagined that impressions made in soft clay were sometimes given to the stone-cutters to copy from, and the transition from this auxiliary use to the actual preferential use of the baked tablet is easy. On the tablet of clay

the "writing" has not undergone a second operation by another hand, but is impressed by the scribe himself.

A large collection of fragments of clay-bearing cuneiform inscriptions has been found by various explorers on the site of Nineveh, being the remains of the Royal libraries of Sennacherib and Ashur-bani-Bal, the earliest being about the 3rd century, B.C. The majority of these "bricks" have no sort of covering, but among the later specimens are several which are enclosed in outer shells of the same clay. These curious instances of ancient "bindings" are usually impressed with a duplicate inscription, but sometimes this is shortened, so that it may indeed be considered a title of the work inside. This form of covering has not helped us in any way to our present form of book, but can only be considered as a curiosity of bygone times.

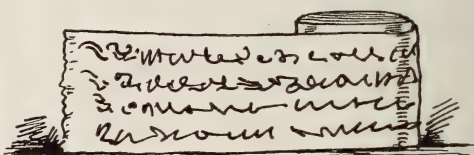
Another form that has been in use for a very long time and yet has equally not affected our present shape is that found to the present day in India, China, and the East generally. It consists now as formerly in the shape of two long rectangular pieces of wood, ivory, or metal, variously ornamented, enclosing separate leaves of the same shape in which the writing is done. These inner leaves are usually strips of palm leaf, but they are variously found of gold, silver, ivory and lacquer, and are kept together by ornamental cords run right through, or metal pins. The outer pieces are ornamented in all kinds of ways, carvings, paintings, metals, repoussé and chased, and inlays in lacquer work are often found, some specimens being of great beauty. In the case of sacred writings the upper cover is often found covered with small pieces of red pigment put on by worshippers, the earliest instances I think when bindings of books have come in for a share in religious ceremonies.

As well as these writings on palm leaves, which are after all only of a limited range, manuscripts were made at a very early period on *papyrus*. This consists of the flattened out fibres of a reed which grew plentifully in Egypt; the fibres were laid double, at right angles to each other, pressed, hammered and dried. The old manuscripts on papyrus are now very brittle, and often they have to be preserved between sheets of glass. The roll was the usual form for these writings, and from the Latin word *volvo*, "I roll," is derived our word for a book—"volume," and although our books are not now rolled up, they are distinctly derived from the roll by a simple evolutionary process.

The fact that papyrus was not a very satisfactory material for writings was discovered as early as the 2nd century, B.C., when for some reason Eumenes II., King of Pergamum, found considerable difficulty in obtaining enough of it, and he is said to have first used *vellum* for writing upon. Vellum is the skin of the calf or goat specially prepared with lime, and is the finest of all known materials for the reception of manuscript. It also was first used in the form of rolls. *Paper* was doubtless first made in China and other parts of the East, and does not appear to have been made in the Western countries until about the 10th century.

The forms in which the writings were made on these three materials are of three chief kinds, and from one of them comes our present shape of book. In the case of the prayers written upon the long strips of paper enclosed in the Buddhist "Prayer-wheels," the writing is in very long lines written, each of them the whole length of the roll (Fig. 1).

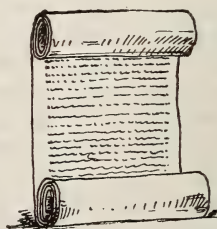
FIG. 1.



Paper roll from Tibetan Prayer-wheel, with writing along the length of the roll. *British Museum.*

In the case of innumerable manuscripts on papyrus and vellum the writing is across the breadth of the roll continuously from beginning to end (Fig. 2).

FIG. 2.



Vellum roll with 15th century Hebrew MS. written across the breadth of the roll. *British Museum.*

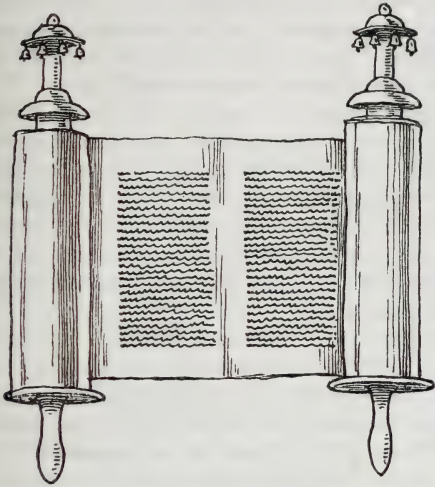
In the case of later MSS. the writing is arranged in page-form, lengthwise as regards the roll, but only in short lines, and this form is the immediate ancestor of our modern page, and consequently the shape of its binding.

The rolls of papyrus were kept together by tapes wound round them, also of papyrus, and often sealed with mud seals. The rolls were sometimes kept in wooden cases in hollows cut

for them, and sometimes in the bases of small statuettes of "Ptah - Socharis - Osiris;" but they do not seem to have had any special form of covering.

The vellum rolls were kept in boxes, also cylindrical in shape, called "*scrinia*," and had frequently title pieces attached to their ends; the wrappings used for the sacred manuscripts in the Jewish synagogues are often very rich and ornamental, as also are the ends of the rollers (Fig. 3).

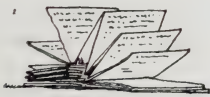
FIG. 3.



Vellum roll, with Hebrew MS. written in page form. *British Museum.*

The page form of writing upon a roll was found to be the most convenient at a very early date by the Chinese, Japanese, and Coreans, they also were the first to find out that if the rolls were simply folded backwards and forwards between the "pages" of writing or printing, the whole book became easier to read, and this form known as "*Orihon*," is used in those countries to the present day (Fig. 4). The

FIG. 4.



MS. in the Batta character (Sumatra), written on a folded roll, and showing the transitional form between a roll and a book. This form is called "*Orihon*" by the Japanese. *British Museum.*

leaves are apparently double, and the outer edges instead of being clean cut as with us, are only a fold, the inner sides of each double page being of course blank. The paper used in these books is usually very thin, so that no practical inconvenience is felt in reading them.

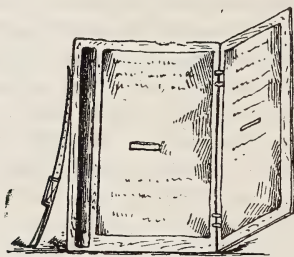
The same idea of folding the roll occurred also in the West, but was carried a step further, inasmuch as the outer fold was cut through, and so both sides of the material came into use. This of course necessitated some form of sewing, or keeping together the inner folds, and the earliest form of this was equivalent to what we should now call "*stabbing*"—that is to say, two or more holes were pierced near the inner edge, right through all the leaves, and through these holes were threaded cords of some kind, afterwards laced together in various ways. This stabbed work can be well seen on almost any modern Chinese book; the chief objections to it are that it absorbs an undue share of the inner edge, and does not open very well, but for thin books not of much value it is very useful. Although this stabbed work was used for papyrus and paper, I have not found traces of it on vellum, but when the vellum rolls were cut up into leaves, as sometimes happened, and it was found necessary to fix their inner edges together, another method was adopted; this was also a very simple and obvious one, and better than the "*stabbed*" method, inasmuch as it took up none of the inner margin. A thread was passed through the inner fold—at first only one fold—and drawn round a strip of leather or vellum beyond, this process being repeated, as often as necessary, produced at last a sewn book resembling in all material points one made at the present day. It was soon found that two or more of these doubled sheets of vellum would fit inside each other, and that one "*sewing*" would fix several of them, so "*quiring*" evolved itself.

The subsequent covering up of these exposed bands and threads at the back of the book, in order to protect them, laid the foundation of the large number of ornamental bindings which have been since produced.

It is curious that the earliest Latin manuscript existing is written upon neither of the materials hitherto mentioned, but is upon wax. In 1875 at Pompeii were discovered a collection of several small tablets of wood hollowed on one side and filled with a shallow layer of wax bearing inscriptions. One of these is the record of a payment to Umbricia Januaria, and is dated A.D. 55—the earliest Latin MS. existing. The "*pugillaria*" or "*diptychs*" usually consist of two leaves (Fig. 5), but sometimes there are more, and in shape they are like our modern books; they are held together at the back by either leather thongs or rings, and many of them have small

hollows for keeping the stylus in. These styles were made of ivory, wood, or bronze, and are generally pointed at one end and flat at the other for making erasures. Later on the diptychs became more ornamental, and were made of richly carved ivory, indeed from the

FIG. 5.



Roman Diptych, or waxen tablet, with wooden stylus.
British Museum.

3rd to the 6th centuries the Roman consular diptychs reached a very high degree of artistic beauty, and are especially interesting because they often have upon them portraits of the consuls who issued them, and are actually the first instances of decorative binding.

The most usual material for the bands and threads used in the sewing of books is I think hemp, or some vegetable fibre, but no doubt strips of vellum and leather were much used in early times; indeed, among the Hebrews, the sacred writings were always sewn with some kind of animal tissue—sinew or gut. This was done in accordance with the Mosaic law as laid down in Leviticus and Deuteronomy, forbidding the use of “*Shaatnez*,” *i.e.*, a material composed of woollen and linen threads mixed. So that for fear of infringing this law the animal tissues were used, and they are often so in other cases; our own Roger Payne unconsciously carrying out the tradition by always sewing his books with silk.

From the time when manuscripts on papyrus or vellum came to be cut into pages, somewhere about the 5th century, A.D., the outer bindings have been used as obvious fields for the decorative artist, and some of the Byzantine and mediæval work of this kind is almost fine enough to be considered among the finest existing specimens of this school of art. Although the so-called “Byzantine” art is not the finest school, in many ways it had immense influence, especially in the Western direction, one development being especially interesting to us, namely, the beautiful Celtic work made under its inspiration.

The earliest decorative bookbinding existing,

the manuscript for which is unfortunately gone, is probably a cover now kept in the cathedral at Milan. It consists of pieces of ivory carved with representations of Biblical scenes in low relief, and in the centre is a lamb within a wreath; this lamb is “*cloisonné*,” that is to say a piece of metal in which flat wire is soldered edgewise in patterns enclosing small spaces, and in these spaces it is said that vitreous enamels exist. I have seen this binding, but unfortunately some time ago, and took the statement as to the enamels without question; but since then I have found that so many of these early so-called enamels are in fact small inlays of coloured stones, that I cannot possibly say whether these are truly enamels or not.

The Byzantine workmen are credited with having kept the secrets of enamelling on metal until about the second half of the 11th century, and until this time they are supposed to have retained the monopoly of the art, which, if found in foreign countries, is supposed to have been done by Byzantine workmen who had emigrated.

At Monza, a town near Milan, is preserved a still finer and more interesting binding. It still encloses the copy of the Gospels for which it was originally made, and was sent, bound, to Theodelenda, Queen of the Lombards, by Pope Gregory the Great, in the 7th century. The letter mentioning the gift calls it “*lectionam S. evang. theca persica inclusam*.” The binding is wood covered with plates of gold, the decoration being alike on both sides.

A large straight cross occupies the place of honour, extending to the edges, and in low relief, the cross is outlined with a line of small cloisons enclosing rectangular flat pieces of garnet, sapphire, and emerald. The inner part of the cross is thickly set with jewels cut “*en cabochon*,” that is to say rounded, not having facets, and some pearls; and at the slightly expanded extremity of each arm is a remarkable oblong jewel of greenish colour, having in the centre a yellow disc on which is a small red flower. These are usually described as enamels, but I think they are not such, being I believe, all cut from a thick glass rod made in the same manner as the “*millefiori*” glass of Murano. Although I do not think they are enamels, no doubt great skill in glassworking is shown in their production. The spaces between the arms of the cross are each ornamented with a Γ (Gamma) and a cameo, the Gammas and the outer border being beautifully ornamented with cut

jewels, flat, enclosed within small gold cloisons. Across the sides are added bars of gold on which is an inscription, "De donis Dei offerit Theodelenda reg. gloriosissima sancto Joanni Baptiste in basilica quam ipsa fundavit in Modicia prope palatium suum."

A similar design, a cross by itself, is found on the earlier side of the binding of the Gospels which originally belonged to the Abbey of the Noble Canonesses, founded A.D. 834 by the Emperor Lewis the Pious at Lindau, on the Lake of Constance. The cross here is not so simple, but is curved in outline, resembling an elongated Maltese cross. There is no doubt that here are genuine enamels of great interest and beauty, both *champlevé* and *cloisonné*, enclosing which are lines of cloisons set with small flat garnets. The work appears to be Celtic under Byzantine influence, the spaces between the arms of the cross being filled with chiselled work in bronze of interlacing lacer-tine forms of pure Celtic character.

The work has been much altered and added to at various times, but the alterations have been well done and are obvious. It is suggested that probably it was originally made by Irish monks in a South German Monastery. It is certainly one of the finest bindings in existence, and now belongs to the Earl of Ashburnham. It was exhibited at the Burlington Fine Arts Club Exhibition of Bookbindings in 1891. The other side of this remarkable book is somewhat later, very ornate, having a crucifixion in gold, and all thickly incrustated with jewels.

Among carved ivories, in which numerous mediæval books were bound, one which is now in the British Museum stands prominently forward both for the beauty of its design and the wonderful skill with which the carving is executed. It covers a Psalter written and illuminated for Melissenda, daughter of Baldwin II., King of Jerusalem in the 12th century, and wife of Fulk, King of Jerusalem after him. It is bound in wooden covers in which are fine Byzantine ivories, measuring eight inches by six, exquisitely carved with scenes from Bible history. There are fillets interlacing with six circles in each side, in each of which a separate incident is shown, the remaining spaces being filled with scrolls and conventional figures, birds and beasts, and enclosing the whole is a beautiful border of scroll and leaf design. At the top of the under side is the name "HERODIUS"—doubtless that of the carver—and points are marked all over with small gems, turquoises, emeralds and rubies, the eyes of the persons and animals being

extremely minute, some of them not bigger than the eye of an ordinary needle, so that it is likely some of the jewels in this binding are the smallest existing cut gems.

On the upper side are six scenes from the life of David, and between them figures showing the triumph of virtues over vices, all of these having little labels with words engraved upon them run in with red pigment. On the other side the six circles contain scenes representing works of mercy, and between them figures of birds and beasts.

In the South Kensington Museum is a splendid specimen of a mediæval Textus, a copy of the Gospels of the 10th century, bound in oak, covered with gold, enamels and gems. The binding in its present state is much restored, but parts are undoubtedly very old and of a Celtic character. It was used at the Abbey Church of St. Maurice d'Agaune, from which it was stolen in the 14th century. Then it was kept at Sion, in the Rhone valley, and was eventually purchased at the Spitzer Sale for the South Kensington Museum. In the centre is a seated figure of our Lord in repoussé and chased gold, round this are two hexameter lines in *cloisonné* enamels of white and green, much restored:—

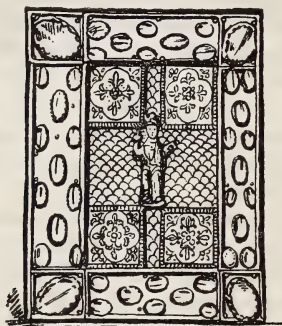
"MATHEVS ET MARCUS LVCAS SCSQ JOHANE
VOX HORV QVATVOR REBOAT TE XPE RE-
DEMPTOR."

The outer border is very broad and is ornamented alternately with rectangular *cloisonné* enamels, and gold plates, jewelled. Of these the four side enamels are original, and so are some of the gold plates, in which is curious superimposed work in gold of curves terminating in heads holding pearls in their mouths. I think probably these few gold plates with the work on them are the only pieces of the binding left which are contemporary with the manuscript; but it is likely enough that the general original design has been to a great extent preserved.

The under side of this book is probably in its original state, it is covered in strong, red leather, studded with nails in the shape of a cross. These books were used as altar books, one at each end, and the upper cover only was usually made very ornamental. They used to be carried round the churches to receive the kiss of peace—a function which, in the Western church, was transferred to the "Pax" somewhere about the 12th century; but in the Eastern church the ornamented Textus is still solemnly kissed on State occasions.

There are several beautiful examples of mediæval bindings in the various church or

FIG. 6.



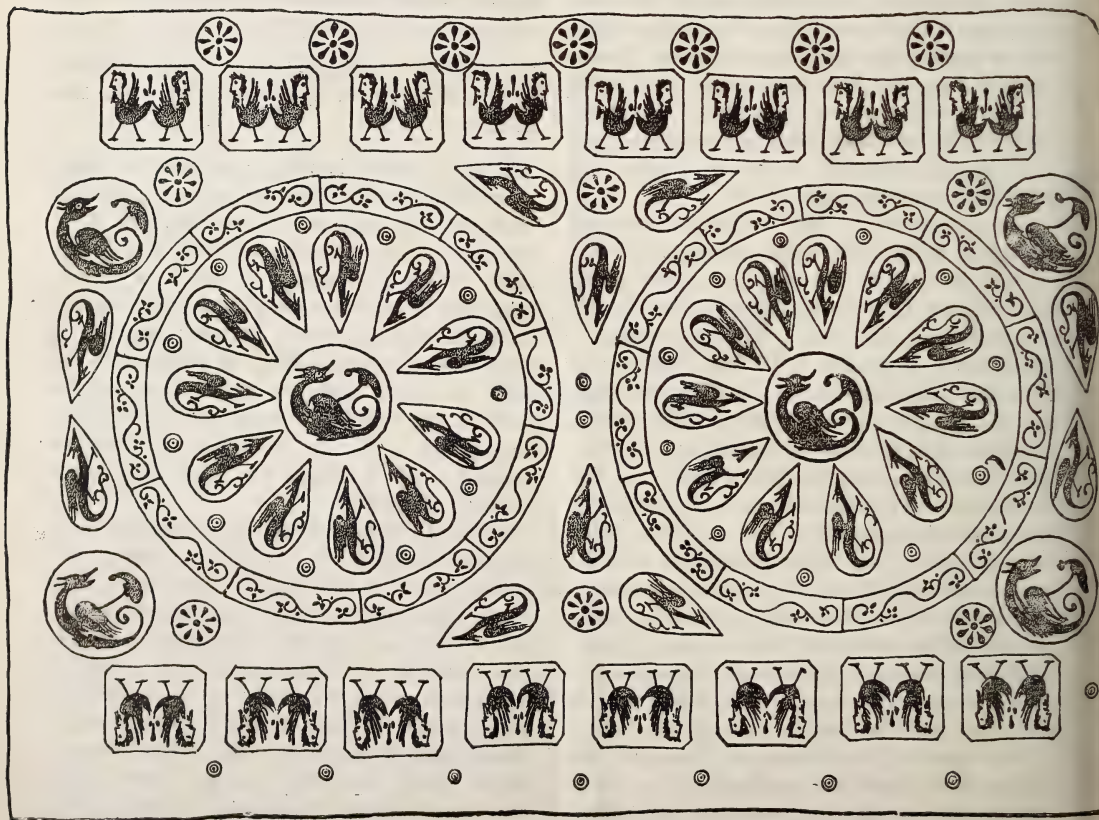
German mediæval binding of the 10th, or beginning of the 11th century. Wood overlaid with plates of gilded copper with large crystals. The four inner corner pieces are subsequent additions, of about the 14th century, in champlévé Limoges enamel. (MS. of the Latin vulgate version of the Gospels of the 10th century.) *British Museum.*

cathedral treasuries on the Continent (Fig. 6), and some few specimens are shown in our great

libraries in England; the majority, however, are not with the manuscript they originally covered. In Russia there are some few ancient and fine examples. One of these, at Moscow, has most interesting enamels of the 10th century; in another, also at Moscow, a copy of the Gospels in Slavonic is the earliest dated binding I have come across; an inscription in Russian round the edge begins, being translated, with the words "In the month of March, 1392, this copy of the Gospels was published by the order of Theodore Andreievitch."

In the Royal Irish Academy at Dublin, are several fine examples of cases or covers for books adorned with metal work and gems in a similar way to actual binding, with charming Celtic designs in bronze and silver. In England there is an absence of any specimens of this kind of work; if any existed, as it probably did, it was destroyed because of the intrinsic value of the materials used; much of this destruction doubtless took place under the early Tudors. Such books as now remain of English work are always simply bound in

FIG. 7.



The Winchester Domesday Book. English blind stamped binding of the 12th century. *Society of Antiquaries.*

leather. The best known examples of this early work are perhaps the Winchester Domesday Book of the 12th century, goat-skin ornamented with small impressions in blind, now in the library of the Society of Antiquaries (Fig. 7); the Gospel of St. John, written probably in the 7th century, but bound possibly about the 10th century, in red leather repoussé and "chased" with a little colour, now at Stonyhurst College; and the Latin Psalter of the 12th century on which our sovereigns, from Henry I. to Henry VII. appear to have taken the coronation oath. This curious book is bound in thick oaken boards covered probably with deer-skin, and in the lower cover is a brass figure of our Lord in the attitude of the crucifixion. It is now in the British Museum.

From the 12th to the 15th century, roughly, many enamelled bindings were made at Limoges in France. They are generally of the kind known as *champlevé*, and the same designs are often used over and over again. The later enamelled bindings from Limoges mark the beginning of the end of this kind of decorative work on books, because in the 15th century came the introduction of printing into Europe, which very soon caused books to become much commoner, much smaller, and, as a rule, bound in a far cheaper and simpler manner.

SCHOOLS IN EUROPE OF STAMPED BINDINGS.

Mr. W. H. James Weale, until lately art librarian at the South Kensington Museum, has made extensive researches on the subject of blind-tooled binding in Europe from the 12th century onwards, and he is of opinion that the English school is pre-eminent for its work in this manner. From London (Fig. 8), Winchester (Fig. 7), and Durham we still possess fine specimens, the various arrangements of the small dies used being most interesting and curious. In most of the English bindings of this kind oval or drop-shaped dies are found; these combine charmingly with circles, and parts of circles, a fashion carried on by Thomas Berthelet and also at Little Gidding. In France the arrangement of the small dies was often in perpendicular lines, and the designs were frequently heraldic. The stamps used on German bindings were often used in combination with beautiful cut-work on calf, and when on pigskin were also frequently tinted with colour, as they are sometimes in the bindings of John Richenbach of Gyslingen, who signed and dated many of his bindings,

one existing as early as 1467. Larger and more elaborate stamps were introduced by various German binders in the 15th century, particularly Johannes Fogel and Anthony Koburger.

The blind stamps on early Italian books are usually of an oriental character, Arabic knots and "basket" work. In the Netherlands the

FIG. 8.



Historia Evangelica. By Petrus Comestor. English blind stamped binding of the 13th century. (London.) *British Museum*.

large panel stamps seem to have been first used, probably during the 14th century; and in the succeeding century these large stamps are plentifully found on French and English bindings. Many of them are signed with the name of the binder, e.g., "Ob laudem Christi hunc librum recte ligavit Johannes Bollecaert." The subjects of the panels are nearly always Biblical. In English panel stamps heraldic ornamentation is often found as well, and rarely floral designs. Saints are commonly represented on stamps of later date—St. George, St. Barbara, St. Anthony, and numerous others—and in

German books Lucretia is a favourite personage, Justice and other virtues also finding a place.

So that with the use of leather for binding books new methods of decoration came in play; the earliest leather bindings both in the East and in the West are simply ornamented with plain impressions from small metal stamps, as we have seen, but after a short time a metal leaf was used as well. The earliest example of this "gold tooling" which I have been able to find exists on a copy of a part of the Canon of Avicenna, written in Arabic in the 12th century, and bound in brown calf. The decoration is a beautiful arabesque, part of which is darkened by heat and the outlines are marked in gold. It is in a bad state and has been rebound. There are other Arabic bindings in goat or calf, ornamented with delicate designs in blind, supplemented with small gilded rings and points. These rings are afterwards found in Italian work of the 15th century, copied no doubt from the earlier Oriental work, and it is supposed that from this source the beautiful art of gold-tooling on leather took its rise. The gold used both on the Oriental and Italian books up to the 15th century is much thicker than what we use now, but it is evidently impressed in a similar way, and fastened on with some unknown substance. Now we use albumen to fix the gold leaf on the leather, the tools being heated so that they congeal the albumen whenever they come into contact with it, thereby fixing the leaf most perfectly.

The gold tooling introduced into Italy from the East, rapidly grew into favour in France and England, but in Germany it did not find so congenial ground. The German work of the 15th century is notable, however, for the skilful cut leather, usually calf, sometimes used alone, sometimes in combination with stamped work in blind, and sometimes with colour or stain. The use of pig-skin stamped curiously and delicately is also characteristic of German work; a celebrated binder—Jean Richenbach—not only designed his bindings but also often dated them, adding, moreover, a little delicate colour here and there on his white pig-skin.

In Persia there was a considerable output of bindings very deeply impressed with large engraved stamps having arabesque patterns upon them. These bindings are usually of paper boards covered thinly with inferior leather, and are often stamped with coloured metal leaf on which is hand colouring in

places. This fashion of large coloured stamp became a favourite in Egypt and in the East generally; the centre ornament is always an elongated oval with more or less elaboration around it. Many fine Italian bindings of the 15th century are copied very exactly from these Persian originals.

LANTERN SLIDES SHOWN AT THE FIRST LECTURE.

1. Egyptian papyrus roll bound with tape and having mud seals. B.C. 1200 (?).
2. Egyptian papyrus roll in wooden case with lid, and statue of Ptah-Socharis-Osiris above it. B.C. 1200 (?).
3. Assyrian tablet with cuneiform inscription, and its outer cover also of clay. B.C. 680.
4. Sanskrit MS. on palm leaves with painted outer pieces. A.D. 1196.
5. Buddhist prayer wheels.
6. M.S. from Sumatra in the form of a folded roll, or "Orihon."
7. Roman diptych or waxen tablet.
8. Jewish scroll of the law, with ornamental rollers.
9. Modern binders' sewing press.
10. Unfinished binding showing the best kind of sewing on raised bands.
11. Unfinished binding showing inferior sewing with sawn-in bands; also showing method of attachment of the ends of the bands to the boards.
12. View of a bookbinder's shop of the 16th century, by Jost Amman, from Schopperus, "*De omnibus mechanicis artibus*." Nearly the same appliances as are used now.
13. Roman consular diptych of carved ivory, showing the apotheosis of the Consul Romulus. 4th century A.D.
14. Ivory diptych with fine Byzantine carving of an archangel. 5th century A.D.
15. Cover of a textus, carved ivory and Cloisonné enamel, from Milan. 5th century A.D.
16. Ivory diptych of the Consul Anastasius. 6th century A.D.
17. Carved ivory binding signed "Herodius" and richly ornamented with rubies, emeralds, and turquoises. Psalter in Latin. 12th century A.D.
18. Golden binding of a copy of the Gospels at Monza, richly ornamented with gems, camei, and glass work. Belonged to the Empress Theodelenda. 7th century A.D.
19. Golden binding of a copy of the Gospels now in the South Kensington Museum. Fine repoussé work, with gems, enamels, and Celtic gold work. 10th century A.D.
20. Binding of the Lindau Gospels. Earlier side. Fine Celtic work under Byzantine influence, with gems and enamels; bronze and copper gilt. 8th century A.D.
21. Binding of the Lindau Gospels. Later side. Gold and silver gilt German work, very richly and

thickly ornamented with repoussé work and fine gems. 10th century A.D.

22. Golden binding of Gospels of the abbey of St. Emeran at Munich. Repoussé work and gems. 10th century.
23. Binding of the Gospels in Latin. Copper gilt with sunken panel, the outer border set with large crystals cut *en cabochon*; Limoges enamels added in the corners. 10th century.
24. Cover of the Stowe Missal now at Dublin. Copper and silver gilt, with inscription and repoussé work; few gems. 11th century A.D.
25. Cover of Molaise's Gospels. Bronze, silver, and silver gilt; repoussé work and few gems. At Dublin. 11th century A.D.
26. Binding of thick wood, covered with leather, and having brass gilt corners, clasps, and figures of our Lord; Latin Psalter. The book on which our sovereigns took the coronation oath from Henry I. to Henry VII. 12th century A.D.
27. Byzantine copper gilt repoussé bindings on Gospels in Greek. 12th century A.D.
28. Byzantine enamelled binding on MS. of the Gospels now at Moscow; much repaired. 12th century A.D.
29. Binding in *champlevé* Limoges enamels on copper, with sunk panel; the heads in relief. 13th century A.D.
30. Russian binding, dated 1392, with enamels; Gospels. 14th century A.D.
31. Silver-gilt binding of the Gospels. German repoussé work; partly gilt, with gems and enamels. 14th century A.D.

Oriental.

32. Blind stamped goat-skin binding of Coptic homilies on papyrus, from Thebes. 8th century.
33. Arabic gold-tooled work on calf; Canon of Avicenna. Arabesques. 12th century A.D.
34. Syriac blind-tooled work on calf. New Testament, with "maltese" cross. 13th century A.D.
35. Arabic blind-tooled work, with small dots, in calf; traditions of the Prophet Muhammed. 14th century A.D.
36. Persian binding in sheep-skin; sunk panels; richly stamped in relief, and gilt all over, with different coloured golds. 18th century A.D. (?)
37. Persian binding in pasteboards; painted inside and out; varnished; poems of Hafiz. 18th century A.D. (?)
38. Persian binding in pasteboards; painted inside and out, with floral designs; varnished; poems of Nizāmi. 18th century A.D. (?)
39. Indian binding in pasteboards; painted inside and out; outer covers have elaborate pictures of the Battle of Karnul; varnished; history of the Muhammedan Dynasties, &c. 18th century A.D. (?)

NOTE.—Besides the slides shown, as mentioned above, the lecturer showed a paper roll with manuscript written upon it in the page form. This roll

was folded between the pages, backwards and forwards, then "stabbed," the ends of the threads being afterwards drawn in to two boards, producing eventually a small finished book.

Miscellaneous.

BAMBOO PAPER.

There have been many notices in the *Journal* on the use of bamboo in paper-making, one of the earliest references being in August, 1866 (vol. xiv., p. 634). The late Mr. Thomas Routledge communicated several letters on the subject, and in 1875 he published a pamphlet which was printed on bamboo paper. The following information respecting more recent experiments on bamboo fibre are from an article in the *Chemical Trade Journal*:—

Paper-makers who have tried to reduce the cane to pulp have found that the conditions of boiling with regard to the quantity of caustic soda required, were somewhat different to the usual methods in use in paper mills.

The boiling, too, was to a great extent regulated by the quantity or hardness of the cane under treatment. Hard, well-matured canes are somewhat difficult to handle. Specially constructed boilers are found to be necessary owing to the great amount of labour required to deal with the canes in a practical way. Hence paper-makers, who have been enterprising enough to practically try the virtues of bamboo as a paper-making material have, so to speak, only nibbled at the work, no quantity of any moment having been regularly converted into pulp and paper.

Owing to the introduction of cheap wood cellulose the chances of a new fibre-yielding stock making any marked headway are now much less than in former years. Wood is so very cheap, as also the methods of obtaining good paper fibre from it, that only an exceptional kind of raw stock has a chance.

Bamboo possesses some characteristics so distinct from wood cellulose, no matter by what method the latter is produced, that there is some justification for thinking it a likely fibre to take a prominent place in the art of paper-making. The fibre is long, strong, and flexible, and possesses good felting properties. Besides, it bulks fairly well and can be treated in the beater with ease to yield a good close sheet of paper. In the raw bleached state it feels very spongy and substantial.

The characteristics of the plant vary a good deal. Much depends upon its growth and at what period of its age it has been cut. It is usually brought to this country in a matured state, as strong, hard canes, which are difficult to cut and as difficult to digest. If, however, as has been suggested, the plant were in some way crushed, and, in a measure, prepared for the

paper maker, its reception as stock would be much more favourable than it is.

Any data relating to this interesting plant, and bearing upon its features as a source of paper pulp, have a special claim upon the attention of the paper maker, because of its great abundance, rapid growth, and comparative cheapness.

Bamboo cane belongs to the same botanical order as straw. The length of the fibre is 0.354 inches, and the diameter 0.0063 inches. The fibres themselves are fine, regular, and smooth, their walls being uniform, and the central canal small. These fibres are mixed with a good deal of intercellular matter, which can be washed away by continual washing. As this, however, tends to yield a close sheet of paper, excessive washing should be avoided.

Müller has given the amount of cellulose found in bamboo as 50.3 per cent. in the air dry cane, containing 8.53 per cent. of moisture. It seldom contains more than 2.0 per cent. of mineral matter, notwithstanding its hardness.

The outer cuticle is composed of a silicate. In one sample examined, the per-centage of ash equals 1.60, of which 51.25 per cent. consisted of silica, and 9.25 per cent. of carbonate of lime, while 6.07 per cent. was carbonate of magnesia. The above yield of cellulose, namely, 50.3 per cent., is never obtained in practice, owing to the solvent action of the caustic soda, and the system of washing in vogue in mills. There is a very appreciable difference in the yield of pulp by the bisulphite process, as compared with the soda process.

As a general rule the cost of treatment with caustic soda under pressure is higher in proportion to other fibres of the same order. The walls of the cane are thicker and harder, their texture being so dense that it is difficult for the soda fluid to penetrate into them. A stronger solution of caustic soda and a higher temperature are therefore employed to reduce the stock to pulp. The proportion of caustic to dry cane varies with the size or age of the latter. The spent soda lyes, too, are more difficult to deal with than those from esparto, the extracted matter being of a different character. Lyes from bamboo are apt to froth excessively when being treated for the recovery of the soda in Porion and other soda recovery plants.

The following practical data relate to the boiling of cane which, when whole, measured from three to four inches in diameter. The cane was crushed between rollers before shipment, and without further preparation was put into the digesters. Contents of charge: Weight of cane put in boiler, 55 cwt.; volume of caustic lye, 1,600 gallons; total pounds of 60 per cent. caustic soda in lye, 1,741 pounds; steam pressure, 90 pounds above atmosphere; maximum temperature, 331° Fahr.; number of hours under pressure, 15.

The proportion of caustic soda to raw stock was 33.6 pounds of 60 per cent. to one cwt. cane, a quantity which will be admitted on all sides as being very high. Less matured cane would, however, not require so much.

The pulp obtained was dark coloured, resembling soda wood before bleaching. By using fully 25 per cent. of its weight of dry bleaching powder, reckoned on the air-dry weight of the unbleached pulp, it was bleached to a pale yellow colour. The ligneous parts of the plants are difficult to entirely remove by simply digesting in caustic soda, and, therefore, to obtain the maximum effect in bleaching, the contents of the poacher are heated to 120° Fahr. Of this bleached fibre, it was estimated that not more than 40 parts were obtained from 100 parts of the cane. The yield, therefore, is not more than what is obtained from straw on the average.

The mineral contents of the plant, however, are such as to lead one to believe that the bisulphite method of boiling would prove cheaper, and yield a fibre as equally pure and good as the soda process. Direct experiment has proved this to be the case, as the following results show.

The bamboo cane selected for the purpose was 1½ inches in diameter, and as a preliminary, was crushed by passing it through a pair of rollers.

The crushed cane was then placed in a lead-lined boiler, and completely covered with a bisulphite of lime solution, having a specific gravity of 1.040, equal to 8° Twaddell. The boiler and its contents were gradually heated, precisely as in the case of wood boiling, and when the operation was finished, and the boiler emptied, the cane presented every appearance of being well boiled. The pulp was soft, a pale yellow in colour, and was readily washed with water. The actual yield obtained from 100 parts of this cane, was 4.8° parts of air dry pulp, containing 10 per cent. of water.

The unbleached pulp was lighter in colour than the corresponding pulp obtained by the soda treatment, and first turned a very deep red when bleaching powder solution was added to it. With 23 per cent. of its weight of dry bleaching powder, it did not bleach to a good colour, but remained of a yellow tint. It was only by the use of permanganates that a pure white colour was obtained.

WINE FERMENT EXPERIMENTS IN FRANCE.

Experiments made by the wine growers of France during the last few years, and which are still the subject of earnest investigation, are attracting considerable attention. It was formerly believed that the quality of a wine produced in a given vineyard could only be changed by some injurious adulteration. It is now asserted by the highest authorities in viticulture in France that the quality of such wines can be improved without the introduction of any extraneous or injurious substance. It is held that the qualities of the products of the specially famous vineyards are attributable to the local ferment which acts upon the juice of the grape to transform it into wine. It is also found that there are notable differences in

the local ferments, or rather in the effects which they produce upon the must. Acting upon the knowledge of these facts, the United States Consul at Lyons says that ferments have been selected from the products of a given vineyard, and used in the products of other vineyards, with the most satisfactory results. It will not make the most famous wine out of the juice of ordinary grapes, but it will ameliorate the latter and import to it, in a certain degree, the bouquet and taste of the former. It is contended by some that the ferment from a Bordeaux, Burgundy, or Hermitage vintage, will convert the juice of common grapes into those famous brands. Consul Covert adds, however, that while this opinion is generally rejected, none of the many whom he has questioned on the subject, except wholesale dealers, deny that the addition of the ferment brings the wines nearer to the excellence of the brand from which it was taken. Report comes from Algeria that experiments made there a few weeks ago prove that this process, with some modifications, is capable of working great amelioration in very ordinary wines. The method employed is as follows:—The grapes are first washed and freshened in cold water and then crushed in a vat. The must is next introduced under a pressure of four atmospheres in a tubular boiler, where the grapes remain a quarter of an hour in a high temperature. A current of cold water is then passed through the tubes, lowering the temperature. At this time the must contains no ferment capable of development, the treatment having transformed the whole into an absolutely neutral liquid, ready for development by the introduction of another ferment. "The wine thus obtained," says the report, "will possess a bouquet and an aroma hitherto unknown to Algerian wines." This experiment, according to the *Moniteur Vinicole*, was made by a large Bordeaux wine grower. It is said that, in some cases, the ferment may be directly mixed with the must, but it is preferable to make a preliminary preparation as follows:—Two or three days before pressing the main crop, say 50 lbs. of grapes are thoroughly washed in an abundance of cold water before being pressed. This is to free them from the dust and germs which may have gathered upon them. They are then pressed, and the juice is separated from the seeds, stems, &c., by means of a fine sieve. The must thus obtained is put into a thoroughly clean barrel, which should be free from all odour; a proper quantity of ferment is mixed with it, and the whole is allowed to stand until needed for use, say two or three days. M. Jacmin, in a recent number of the *Moniteur Vinicole*, gives the following as the proportions to be used:—One litre (1·76 Imperial pint) of selected ferment is to be used in the juice of from 40 to 50 lbs. of grapes for every 1,600 gallons of the vintage must. The yeast thus set, if properly made, ferments actively under the influence of the selected ferment, and is ready for use 50 or 60 hours after the beginning of the preparation. It must be mixed with the vintage must, immediately after the latter has

been pressed out. The barrel containing the yeast—that is the juice of the first 40 or 50 lbs. of grapes—should be well stirred in order to avoid the loss of the yeast which settles. The yeast should be mixed with the must as uniformly as possible, and several methods are indicated. Some of the yeast is sprinkled on the vintage tubs, presses, barrels, &c., and generally about one-third of the yeast prepared is thus employed, the remaining two-thirds being used as follows:—About one-sixth is put on the bottom of the vat before the crushed grapes are emptied into it; the rest of the yeast is mixed with successive layers as the vat is filled up. What remains is finally poured over the top of the must. An ordinary spraying apparatus affords an excellent means, but it must be either new or very carefully cleaned beforehand. It is well to take the spraying machine into the vineyard and to prepare a tub of yeast diluted with some freshly pressed juice. A single workman with a spraying apparatus is sufficient for a gang of fifty grape gatherers. He sprays the yeast on the bottom and sides of the tubs and other means of transport as the grapes are put into them. All bunches are thus covered with an imperceptible coating of yeast of good quality, and by this means any difficulty arising from the crushing of the grapes during transportation is avoided, because any fermentation which begins is of an excellent nature on account of the precautions taken. The preparation and use of the yeast is the same for white wine as for red, although many makers of white wine content themselves with pouring the selected ferments directly into the must after pressing. The preparation of the yeast is more important in a cold season than in a warm one. This question of the use of ferments is receiving the favourable consideration of many great wine growers in France, and chemists have applied scientific rules to the use of the ferments.

THE STRAW INDUSTRY IN GERMANY.

The manufacture of straw is one of the most important industries of Germany, giving employment to thousands. Straw that once served only for fuel and fertilising purposes, is put up by the German workpeople into the most useful, beautiful, and fantastic forms. Plates, dishes, baskets, boxes, tables, trunks, fans, hats, caps, mats, &c., are made by the million, and sent to all parts of the world. The United States Consul at Chemnitz says that in a stretch of country containing six square miles there are 10,000 persons employed in making articles of straw. Of the straw used, the best comes from Tuscany. They are rye and wheat straws, and are known as the *grano marzuolo* or March grain. It is sown in March, very thick, to prevent the blades from growing too fast or strong. In June it has grown to a length of 18 or 20 inches, and is ready for use. The rye and wheat are torn out by the roots, bound into small bundles, exposed to the sun but not to the

rain, and then laid aside for one or two years' seasoning. Before being worked, the bundles are spread out like fans, exposed three nights to the dew, and three days to the sun. In this way the straw that was green becomes a beautiful yellow or golden white. The ears and roots are now removed, and the stems are sorted into from twelve to twenty different sizes. The sorting is done by means of sieves graduated from coarse openings to fine ones. The straws are then arranged, according to length, into three classes and fastened in bundles, which are steeped in water, allowed to drip, and then placed upright around a practically airtight room in the middle of which is a brasier full of burning sulphur. The sulphur is renewed each evening until the straw becomes a beautiful white. The sorting has separated only the thick from the thin, the short from the long; there remains the difference in size between the top and bottom of each separate stem. To obviate this, the stems are cut again twice, leaving only about 2 or 3 inches of the middle, which has a uniform thickness; these are woven into the finest hats. The other ends are also woven into hats, caps, &c. This process prevails not only in Tuscany, but in Lombardy, Switzerland, and France; the French or Swiss straw is said to be neither so strong nor so beautiful as the Italian. In Italy the straw is worked up whole; in Switzerland and Germany it is split. In Saxony the straw passes through nine processes from the moment it is cut by the reapers. The stems are first drawn through a rake or toothed utensil till the ears, roots, and projecting leaves are removed. The next step is the arranging of the corn in sheaves. The third consists in removing the knots and cutting the stems into three lengths or pieces. The upper or thinnest is the most valuable part. The straw is then dampened and placed for 24 or 30 hours in the upper part of an apparatus, consisting of two compartments one over the other. In the lower is burning sulphur, the fumes of which enter the upper through hundreds of little holes bleaching the dampened straw. The next step consists in again sorting, according to length and thickness and splitting, by drawing the straw over a toothed, saw-like piece of steel. Even the very coarsest straw can be utilised for fine work by splitting. The straws are then plaited into bands, trimmed, wound, and sewn. Formerly the sewing was all done by hand, but rapidly increasing competition compelled manufacturers to introduce machines. In the straw industry, as in almost every other industry in Germany, education is developing a class of skilled labour, whose capacity to compete increases yearly. Saxony alone has six such schools.

THE COST OF THE SIBERIAN RAILWAY.

The United States Consul at Moscow says that the Committee of the Siberian Railway recently held

a meeting and rendered its accounts, which contained the following details of expenditure incurred from 1893 to 1897, showing the total cost of the construction of the Great Siberian Railway:—

Construction of the Western Siberian	£
Railway, without the Baikal branch	5,074,300
Central Siberian Railway	9,776,600
Branch line of Ekaterinburg-Cheliabrusk	653,500
South Ouroussisk branch	2,241,600
North Ouroussisk branch	2,246,100
Irkutsk-Baikal branch	240,600
Steam ferry across the Lake Baikal..	340,400
Yabaikalski Railway	7,244,700
Tomsk branch	260,900
Onon branch to the Chinese frontier	3,272,800
Nieolski " " "	881,100
Perm Cottass branch	3,651,400
Various supplementary expenses	2,116,800

Total expenditure.... £38,000,800

Out of the above amount, there has already been advanced £32,599,100, and, in addition, there have been expended for topographical and astronomical works, irrigation, surveying, geological researches, agricultural implements, &c., the sum of £1,195,700.

General Notes.

SCIENCE AND ART DEPARTMENT.—The Lords of the Committee of Council on Education have received a request, on behalf of the Hungarian Government, for a selection of works for which awards have been made in the National Competition of this year, to be sent on loan, at the expense of the Hungarian Government, for exhibition in the new Industrial Art Museum at Buda Pest, and their Lordships have promised to afford every facility. The Schools of Art are being asked to state in each case whether works may be sent.

COMO ELECTRICAL EXHIBITION, 1899.—Information has been received from the Foreign office through the Science and Art Department, of an International Exhibition of Electrical Appliances, to be held in Como, to commemorate the centenary of Volta's discovery of the electric pile. The Exhibition will be opened on the 15th May, 1899, and will be closed on the 15th October. Applications for space must reach the Executive Committee at Como before the 31st October, 1898, and articles will be received from the 1st to the 30th April, 1899. Machines and other exhibits requiring special foundations or fixing must be consigned before 15th February, 1899. A congress of electricians will be held in connection with the Exhibition. An exhibition of the silk industry will be attached to this Electrical Exhibition. This will be national for products, and international for machinery, tools, and processes relating to the same.

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FRIDAY, SEPTEMBER 2, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.

EXAMINATIONS, 1899.

The dates fixed for the Society's Examinations in 1899 are Monday, March 13th, Tuesday, 14th, Wednesday, 15th, and Thursday, 16th.

The Programme of Examinations is now ready. Copies of the Programme, with full details, and an Appendix containing last year's questions and reports by the Examiners, can be had, price 3d., post free, on application to the Secretary, Sir Henry Trueman Wood, Society of Arts, Adelphi, W.C.

SECTIONAL COMMITTEES.

At the last meeting of the Council the following Committees for the Indian, Foreign and Colonial, and Applied Art Sections were appointed:—

INDIAN SECTION COMMITTEE.

Sir John Wolfe - Barry, K.C.B., F.R.S. (Chairman of the Council).	Sir John Jardine, K.C.I.E., W. S. Seton Karr.
Sir Steuart Colvin Bayley, K.C.S.I., C.I.E. (Chairman of the Committee).	Sir Seymour King, K.C.I.E., M.P.
Sir Frank Forbes Adam, C.I.E.	Sir W. Lee-Warner, K.C.S.I., M.A.
Sir G. W. Allen, K.C.I.E.	Sir Roper Lethbridge, K.C.I.E.
Lionel R. Ashburner, C.S.I.	Sir James Broadwood Lyall, G.C.I.E., K.C.S.I.
Jervoise Athelstane Baines, C.S.I.	Sir James Lyall Mackay, K.C.I.E.
Sir Charles Edward Bernard, K.C.S.I.	Sir Alexander Mackenzie, K.C.S.I.
Sir M. M. Bhowaggee, K.C.I.E., M.P.	J. M. Maclean, M.P.
Sir George Birdwood, K.C.I.E., C.S.I., LL.D., M.D.	General J. Michael, C.S.I.
H. M. Birdwood, C.S.I.	J. Sewell Neville.
Major-Gen. Sir Owen Tudor Burne, G.C.I.E., K.C.S.I.	Field-Marshal Lord Roberts, V. C., K. P., G. C. B., G.C.S.I., G.C.I.E.
Sir Charles H. T. Crowthwaite, K.C.S.I.	Sir George Scott Robertson, K.C.S.I.
Rt. Hon. George N. Curzon.	Alexander Rogers.
F. C. Danvers.	Thomas H. Thornton, C.S.I., D.C.L.
Sir Juland Danvers, K.C.S.I.	Sir Charles A. Turner, K.C.I.E.
Sir Charles A. Elliott, K.C.S.I.	Sir Raymond West, K.C.I.E.
Major-General Sir Frederic Goldsmid, K.C.S.I., C.B.	Sir Alexander Wilson.
Lord Harris, G. C. S. I., G.C.I.E.	Arthur N. Wollaston, C.I.E.
Sir William Wilson Hunter, K.C.S.I., C.I.E., LL.D.	W. Martin Wood.
	Andrew Yule.
	S. Digby (Secretary).

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Sir Charles Malcolm Kennedy, K.C.M.G., C.B. (Chairman of the Committee).	Admiral Sir Erasmus Ommaney, C.B., F.R.S.
Lord Belhaven and Stenton.	Sir Walter Peace, K.C.M.G.
Lt.-Gen. Sir Andrew Clarke, G.C.M.G., C.B., C.I.E.	Sir Westby B. Perceval, K.C.M.G.
B. Francis Cobb.	Sir Saul Samuel, Bart., K.C.M.G., C.B.
Hon. Dr. J. A. Cockburn.	Lord Strathcona and Mount Royal, G.C.M.G., LL.D.
Sir Daniel Cooper, Bart., G.C.M.G.	General Sir John Stokes, K.C.B.
C. Washington Eves, C.M.G.	Sir Thomas Sutherland, G.C.M.G., M.P.
Sir Malcolm Frazer, K.C.M.G.	Sir Richard Temple, Bart., G.C.S.I., C.I.E., D.C.L.
Sir Douglas Galton, K.C.B., D.C.L., F.R.S.	Hon. Sir David Tennant, K.C.M.G.
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Major-General Sir William Henry Rhodes Green, K.C.S.I., C.B.	Sir Charles Rivers Wilson, G.C.M.G., C.B.
Sir Robert G. W. Herbert, G.C.B.	Sir James Youl, G.C.M.G.
	S. Digby (Secretary).

APPLIED ART SECTION COMMITTEE.

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Sir George Birdwood, K.C.I.E., C.S.I., LL.D., M.D. (Chairman of the Committee).	Sir Stuart Knill, Bart., Alderman.
Thomas Armstrong, C.B.	Arthur Lasenby Liberty.
Charles Barry, F.R.I.B.A., F.S.A.	Sir Villiers Lister, K.C.M.G.
Prof. A. H. Church, M.A., F.R.S., F.C.S.	T. Buxton Morrish.
C. Purdon Clarke, C.I.E.	J. Hungerford Pollen.
B. Francis Cobb.	Sir E. J. Poynter, P.R.A.
Alan S. Cole.	Sir Walter S. Prideaux.
Sidney Colvin, M.A.	Prof. W. C. Roberts-Austen, C.B., F.R.S.
Walter Crane.	Vincent J. Robinson, C.I.E., F.S.A.
Lewis Foreman Day.	William Simpson.
I. Hunter Donaldson.	A. B. Skinner, B.A., F.S.A.
Major-General Sir John F. D. Donnelly, K.C.B.	John Sparkes.
Hon. Sir Chas. W. Fremantle, K.C.B.	R. Phené Spiers, F.S.A.
J. Starkie Gardner.	Hugh Stannus, F.R.I.B.A.
	H. H. Statham, F.R.I.B.A.
	William Luson Thomas.
	Sir Thomas Wardle.
	Henry B. Wheatley, F.S.A. (Secretary).

Proceedings of the Society.

CANTOR LECTURES.

DECORATIVE BOOKBINDING.

BY CYRIL DAVENPORT.

Lecture II.—Delivered January 31, 1898.

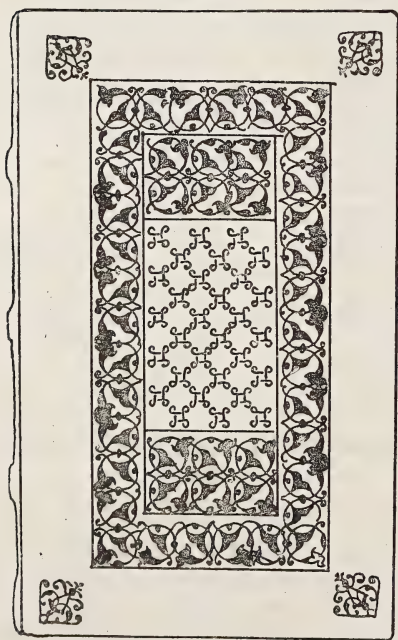
ITALIAN, FRENCH AND GERMAN BINDINGS FROM 1500 TO THE 18TH CENTURY.

1.—Italy.

The chief difference between the books of the latter half of the 15th century and those

that preceded them, is that caused by the introduction of printing, and although to some extent the tradition of rich jewelled and enamelled bindings was carried on in England in the form of books bound in velvet and adorned richly with small pearls, enamels, and rarely jewels, generally speaking, the bindings became far simpler. But, as has been shown, these simple bindings in leather paved the way for the developments of the beautiful art of gold tooling, which, used in an elementary and accessory way by the orientals, in the hands of their Italian copyists reached a high point of art and technique. It is generally considered that the gold tooling on early Italian books was first done on those issued from the press of Aldus Manutius, but there seems little doubt that the art was known and practised by Italian binders before him. Indeed it is difficult to say positively whether Aldus bound any of his books himself. On one of those attributed to him occurs, in blind, the device of a dolphin, and on many what is known as the Arabic knot. This knot, copied directly from oriental work, is sometimes impressed in blind and sometimes in gold. The early Venetian

FIG. 1.



Italian gold tooled binding in morocco. Cæsar. Florence.
1514. *British Museum.*

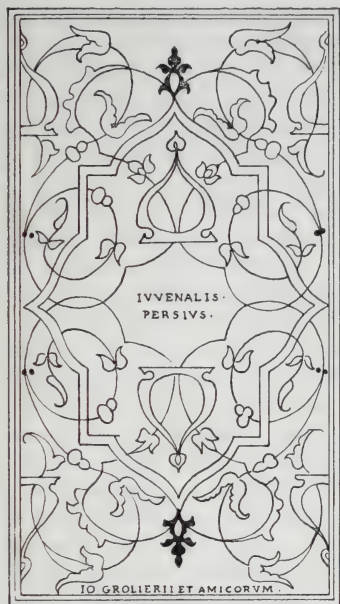
and Florentine bindings are remarkable for the consummate skill and taste with which the few tools used upon them are designed and used (Fig. 1). They have, I think, never been sur-

passed in these qualities, although later work is technically of greater excellence. Many of the borders found on early Italian bindings are repeated and modified again and again, both in English and French work.

So much cannot be said for the Italian bindings made with sunk panels, also after an oriental pattern. In these instances the Italian love of colour has resulted in work that is very brilliant, but often over-coloured. The boards are not of wood, but pasteboard, and the sunk panels are often made by means of double boards, the upper of which is pierced. The edges of the double boards often show a depression along their centres where the two boards join, and curiously enough this depression is often artificially produced in later Italian, French and English work as a decorative feature in itself. The ornamentation upon these books is frequently finished by hand painting in gold and colours, and on such of them as contain official documents the lion of St. Mark is often shown in the centre oval. The art of the Venetian binders, however, is considered to have reached its highest point in the bindings made for Jean Grolier, Vicomte d'Aguisy, who spent some time in Italy as ambassador from Francis I. to Pope Clement VII., and was afterwards Treasurer-General of France. He was a scholar and a man of taste, and is well known as being not only the first great collector of books, but also the first amateur to have his books bound for himself in a particular manner. The designer of his bindings is unknown. It has been suggested that Geoffrey Tory may have had something to do with them, and it has also been thought that Grolier himself gave the general idea of the decoration. The earlier "Groliers" were no doubt bound in Italy, and on them the small fleurons and tools are cut solid. At a later time the tools were cut with lines across them; these are usually considered to be French work, but it is difficult to decide, as it is likely that Grolier took an Italian finisher with him on his return to France. The backs of Grolier's books are sometimes ornamentally treated. On one board, at the lower part, is the legend "IO GROLIERII ET AMICORVM" (Fig. 2), and on the other board are usually the words "Portio mea domine sit in terra viventium" stamped in the centre. Many of the brown morocco bindings are marbled with a dark stain, and at the beginning and end of each volume is a section of vellum, making the joint very strong, and sometimes stiff to open. The fillets on some of Grolier's bindings are

stained black, but with this exception no colour besides the gold is used on any of his Italian bindings, although red and blue occur on some French examples.

FIG. 2.



Gold tooled binding in cloured morocco executed for Jean Grolier, Vicomte d'Aguisy. *Juvenalis et Persius. Venetiis. 1535. British Museum.*

Tommaso Maioli, another great collector, used a similar inscription to that of Jean Grolier, and put on most of his books the words "THO. MAIOLI ET AMICORVM," and on some of his books inlays of coloured leather are found, one, a copy of the "*Hypnerotomachia Poliphili*," printed in Venice in 1499, but bound later, is in dark blue morocco with the centre panel of the upper board inlaid with citron morocco. Several of the simpler bindings made for Maioli have the grain of the morocco slightly filled in with gold, and the leathers are sometimes marbled with a dark stain. Many of his bindings are picked out with background thickly powdered with small gold dots.

The early Italian bindings are sometimes ornamented with "cameo" impressions on the leather. These impressions are themselves often made in a hollow cut or pressed into the side of the board. One of the most tasteful instances of the use of this kind of ornament occurs on the red morocco binding of a Greek "*Anthology*" printed at Florence in 1490. On one side, in a circular hollow, is a cameo portrait of Alexander the Great, and on the other Philip of Macedon—the gold and blind

tooling in this book is most charming. Other instances of portraits made in a similar way are found, but the best known are the stamps found on books which belonged to Demetrio Canevari, physician to Pope Urban VII. These stamps vary in size according to the shape and size of the books on which they are used—the bindings were probably made in Venice between 1534 and 1560—the rest of the gold tooling is distinctly of Venetian character, but they were not made for Canevari himself, who was not born until 1559.

The design on the "Canevari" stamps represents Apollo driving a golden chariot, with a white and a black horse, towards a hill on which is a silver Pegasus, the colour being added by hand. Apollo has a golden helmet and a golden cloak, and holds a golden whip in his hand. On the larger stamps, some silver clouds are shown in the sky, but these do not occur on the smaller stamps. Round the stamps on a ribbon are the words *ΟΡΩΣ ΚΑΙ ΜΗ ΛΟΞΙΩΣ*, and gold tooled work of fine design usually encloses the whole, with sometimes the title of the book in an ornamental cartouche. The colouring on the cameo is frequently very faint, but some of it can generally be found in protected corners. Traces of all the original colour can be still seen in the splendid copy of "*Polydorus Vergilius de Historia Anglica*," now exhibited in one of the binding show cases in the King's Library at the British Museum (Fig. 3).

FIG. 3.



Cameo stamp of Apollo driving a chariot, and Pegasus, found on bindings that belonged to Demetrio Canevari, physician to Pope Urban VII., in the 16th century. *British Museum.*

The later Italian bindings are largely heraldic, from the interesting 16th century embroidered book with the arms of Cardinal Perretti, afterwards Pope Sixtus V., to those made for Henry Benedict, Cardinal York, there are numerous examples. The papal bindings are, some of them, decorative enough, with the tiara and cross keys, the arms in each case being those of the family of the Pope. But generally the art of decorating bindings in Italy, from the 16th century onwards, suffered a rapid and remarkable fall, which it has never recovered. The Italian work not heraldic, of this period, is frittered away in minute stamps, inferior in design, and weak in combination. A little inlay of coloured leather is sometimes found, and also there are instances of stained and painted leathers.

2.—*France.*

In France the art of bookbinding has been highly appreciated for a long time, and many beautifully-illustrated books treat of the subject.

Heraldry plays an important part in the history of French bookbinding, and for this division of book decoration a most valuable text-book exists in the "*Armorial du Bibliophile*" by J. Guigard.

Such a book of reference for English "*super libros*" is much wanted. To French workmen we in England owe, no doubt, much of our excellence in book decoration, as in many instances there have been large accessions to our native workmen, due to the immigration of Frenchmen, especially about the time of the revocation of the Edict of Nantes in 1685, and these workmen prospered here so well that I believe without exception they came to stay.

From 1401 until 1791 there existed in Paris a guild known as that of St. Jean Latran—an account of it will be found in Thoinan's "*Les Relieurs Français*"—and no doubt the encouragement given to "booksellers, printers, scribes, illuminators and binders" by this guild has largely contributed to the generally high level of French bookbinding, both from the technical and decorative points of view. An interesting outcome of the existence of this guild, which was equivalent to our trade unions, was the fact that the art, its secrets, and special styles were often preserved from father to son in the same family continuously for several generations.

The early 16th century French bindings are generally in calf, stamped in blind. The smaller stamps are often arranged in perpendicular lines, and this characteristic is found

in the few existing bindings made for Louis XII. A commoner form is the large panel stamp, usually of some scriptural subject and often bearing the name of the binder on a border. Such are the works executed by Jean Norius, Louis Bloc, André Boule, R. Macé, and several others, and in these bindings, always in blind, is no sign of Italian influence.

But from the earliest introduction of gold tooling in French bindings the designs are strongly of Italian character, the actual workmanship rapidly becoming of the highest technical excellence.

Francis I. possessed several fine bindings ornamented with gold toolings; they bear his badge of a salamander, and often also his crowned initial. They are sometimes supposed to have been bound by the artist Geoffrey Tory, who was "Engraver and Royal printer," and also bound books ornamented in gold with his own special designs, largely taken from Italian models, but nevertheless characteristic of himself. Whether Tory bound any of the fine bindings of Francis I. is not certain, but he is credited with having to some extent designed for Grolier. Indeed in his "*Champfleury*," he mentions that he had been employed by Grolier to design some letters. On Tory's bindings is sometimes found his badge of a vase "*qui est cassé, par lequel passe ung toret*," the "*toret*," a play upon his name, being the instrument with which the china was pierced previous to putting in the rivets.

The French bindings executed for Jean Grolier are like the Italian ones, but have some small differences—the most notable being that the small leaf-shaped tools which are "*solid*" in the Italian examples are "*azurés*" or scored across with lines, in the French. Another peculiarity is that the fillets in ribbons which interlace so effectively in many of these bindings are sometimes marked in the French examples with colour, black, red or blue.

The love of colour probably reached its strongest manifestation in the bindings made for Henry II., Catherine de Medicis, and Diane de Poitiers, Duchess de Valentinois. On the bindings of each of these collectors the heraldic element enters largely. The colour is some kind of enamel when used simply as an additional ornament to the gold tooling, but when an entire coat of arms is painted, as in the case of Catherine de Medicis's copy of the works of Dionysius Areopagita, printed in Paris in 1562, now in the British Museum, then simple oil colours alone are used. On the bindings made for Diane de Poitiers, her

design of an arrow with laurel and a tomb often is found, with sometimes her coat of arms, "Brezé impaling Poitiers." On the later bindings, however, are generally found bows, arrows, quivers, interlaced crescents and the cypher of the two D's reversed, the solution of the monogram being still unsolved, and generally there is a preponderance of white in the colouring.

On the bindings of books for all these three personages occur monograms, much resembling each other, concerning which there has been much controversy. On those bound for Henry II. are two D's reversed crossed by a bar, probably standing for "Henri Deux." On those bound for Catherine are H and C interlaced, and on those bound for Diane are simply two D's reversed. But on most of the bindings made for all these three personages the king's monogram with crown occurs as well as the others.

The "semis" or powdering of a small tool symmetrically over the field is found first in French books bound for Charles IX., and these were probably executed by Claude Piques, his "binder in ordinary." On some of Charles IX.'s books the royal coat of arms is painted in oils in the centre, and the "semis" is of crowned C's. At Lyons during the 16th century, and later, were produced numbers of beautifully coloured bindings, usually small, of interlacing fillets painted in some kind of enamel.

All the children of Henry II. and Catherine de Medicis seemed to have liked fine bindings, and it is even said that Henry III. was himself an amateur in the art. His bindings often have upon them a death's head and religious mottoes. In his reign lived Nicholas Eve, one of whose bindings is in the British Museum. This binding covers a copy of the Statutes of the order of the Saint Esprit, instituted by Henry III. It is one of the forty-two copies bound "et couverts de maroquin orange du Levant, enrichis d'un côté des armoires de Sa Majesté pleines dorées, de l'autre de France et de Pologne, et aux quatre coins de chiffres, et le reste de flammes, avec leur fermoirs de ruban orange et blue, suivant l'ordonnance de M. le Chancelier, du 26 et quittance du 27 déc. 1579."

The orange of the leather of this book is now faded, and the ties of orange and blue are nearly worn off, otherwise the book is in perfect condition. It is curious that the general style of decoration attributed to the Eves is not like that in this book, but is the kind known as

"à la fanfare," richly and thickly covered with curving sprays of laurel and palm, spirals of conventional foliage and arabesques of graceful forms.

The workmanship of these bindings is very skilled, but the design is usually too full, and not always as consistant as it might be. There is very rarely any colour found in them. The style seems to be common during the time when Nicholas Eve was "Relieur du Roy," and in Thoinan's "Les Relieurs Français" there are given several names of binders of the time who may have used it, as also may Clovis Eve, the next Royal binder but one to Nicholas.

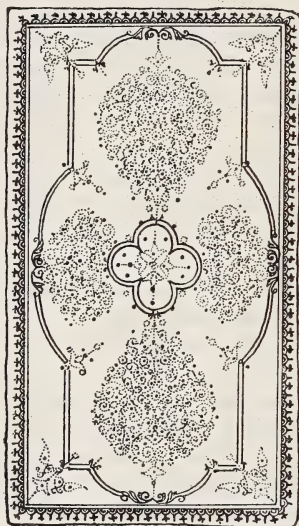
Several very fine instances of elaborate bindings in the "fanfare" style were made for Jaques Auguste de Thou, President of the Parliament of Paris in the 16th century; for him the largest specimens I have ever seen were done. De Thou was a great collector of books, and besides the magnificent bindings, usually credited to Clovis Eve, that were made for him were numerous simpler ones, nevertheless most charmingly bound in splendid leathers, the colours of which were, to some extent, chosen according to the subject of the books they covered.

The centre ornament of these books is the coat-of-arms of their owner. At first the paternal coat alone, a chevron between three gadflies, and below it a monogram; then two coats, his own and that of his first wife, Marie Barbançon, with again a monogram, but this time containing an M in addition to the I.A.T.; and lastly, again two coats, his own and that of his second wife, Gasparde de la Chastre, and a monogram containing her initials as well as that of her husband.

In the 17th century appeared the binders Le Gascon and Florimond Badier, particularly. Their work and methods were very similar—indeed, some authorities consider them to be the same man. As far as I have been able to see, however, Badier's work is coarser than that of "Le Gascon." Badier fortunately sometimes signed his work, so that his manner can be distinctly ascertained. Le Gascon is mentioned in the register of the Guild of St. Jean Latran in 1622. Badier married the daughter of Jean Gillede, binder, in 1645. Mr. Herbert P. Horne in the "Binding of Books," thinks it not unlikely that Gillede was "Le Gascon." There is no doubt that most exquisite work was done, usually on small books, by some very skilled workmen who invented a new style between about 1630 to 1665. The chief peculiarity from the finisher's point of view

about the designs in these bindings is the use of "dots." Not only are "dots" effectively used by themselves, but even the smallest tools, which were hitherto used solid, are scored across so that the impression instead, for instance, of being a consecutive one line spiral, becomes a spiral of brilliant points. The result is an effect of glittering lacework, and no style in all the history of decorative ideas applied to bookbinding has been so much copied as this of Le Gascon.

FIG. 4.



Gold tooled binding in morocco, by Le Gascon, in the "pointillé" method. *Novum testamentum Græce*. Amsterdam. 1633. *British Museum*.

His moroccos are sometimes clouded, and sometimes in mosaic, the edges of the leaves being generally gilt, sometimes with marbling under the gold, and sometimes painted. There is a strong resemblance in the "pointillé" curves to work executed in silver filagree with twisted wires, but whether this gave the idea to Le Gascon is an open question, I think very likely it was so.

The Ruettes—father and son—bound much in the style of Le Gascon, but without the mosaics.

The Count de Hoym had several of his bindings made by Boyet, whose work is notable for its excellent technical qualities, as well as for the doublures, or inner ornamentation, with which they are often decorated. This binder is also supposed to have bound for Hilaire Bernard de Requeleyne, Baron de Longepierre, an amateur writer of plays, one of which only reached some amount of popularity. This was called "Medea," and in allusion to it his books

usually have upon them a charmingly cut stamp of a golden fleece. Du Seuil, although his name occurs in many sale lists, and he was actually one of the binders in ordinary to Louis XV., has left no instance of work that can positively be known as his.

The family of the Padeloups gave five generations of binders to the world, the most celebrated of them was Antoine Michel, called "le jeune." He was appointed binder in ordinary to Louis XV. in 1633, in conjunction with Du Seuil, who had married his cousin, and he was one of the wardens of the Guild of St. Jean. Padeloup le jeune often attached his ticket to his bindings, so that we can sometimes in his case be quite sure of the binder. He invented what is called the "Dentelle" bindings, the borders being very broad and extending inwards from the outer edges of the boards towards the centres in an irregular manner, somewhat resembling a piece of lace edging. Padeloup also decorated several of his books with symmetrical patterns repeated all over each board with small inlays of coloured leather. The taste for these inlaid or mosaic bindings rapidly spread in France. Among the best of the many excellent workmen who made them during the 18th century, may be mentioned Le Monnier, who recovered his freedom in 1757, Jacques Antoine Derome, and Nicholas Denis Derome. The Deromes' bindings resemble those of Padeloup in many particulars, the dentelle style of border especially is often used, and often the stamp of a little bird with outstretched wings is worked into it; when this occurs it is called "Dentelle à l'oiseau." There were about fifteen members of the family of the Deromes who were binders, but the two mentioned are best known, the latter being called "le jeune." Derome le jeune often put tickets in his books; he is considered to have sinned in the technical peculiarity of having cut the edges of his book too far inwards towards the text—this is called "cropping." He is also generally supposed to have been the first great binder to use the saw in the backs of his books, so as to sink the bands to more easily produce the flat backs. This plan was, however, actually used in England on embroidered books in the 17th century.

The Lemonniers, twenty of which family are known binders, were all excellent workmen, the best known being a father and son—Louis François and Jean Charles; the younger of these two used sometimes a ticket inside the book, and sometimes the name "Le Monnier"

stamped on the outside of the bindings themselves.

One exquisite specimen of a Le Monnier binding is exhibited in one of the binding show-cases in the King's Library at the British Museum. It is a copy of the Bible printed at Cologne in 1739, the design being the same on each side. The binding itself is red morocco, and on each board is a gracefully vandyked border inlaid with cream coloured calf, in the corners and spaces on which are small flower groups with leaves all inlaid in differently coloured pieces of morocco, on which is delicate gold tooling, the lines of junction of the little pieces of leather being always carefully covered with a gold line. In the red space within the border is a very graceful spray of conventional flowers, with buds and leaves, all inlaid in a similar way, and gold tooled as well. On the rib of one of the larger leaves is the word "MONNIER," and it is also on the lower edge of the books, impressed in gold. The whole of the red ground is covered with a series of gold dots.

The books which belonged to the three daughters of Louis XV., are sometimes met with out of large museums. They are simply and prettily bound with the same Royal coat of arms, but are remarkable because they are bound in leather of distinctive colours. Those which belonged to Madame Adelaïde being in red, those which were the property of Madame Sophie and Madame Victorie, respectively, being in citron and olive.

Later, the tradition of fine bindings among the French has been well maintained by the fine work of such binders as Duru, Thouvenin, Trautz-Bauzonnet, Capé, and many others, technically of the highest excellence, but from the artistic aspect wanting in originality and life.

3.—*Germany.*

As a whole, the most noticeable peculiarity about the German bindings from the 16th century onwards is the prevalence of panel stamps with portraits. On the earlier cut leather work exist several figures—saints and monks—but the identity of these, I think, is not known; it is, indeed, possible they are not portraits at all, but the large majority of the panel stamped portraits are named. Dates are also often found on them, and they are always on calf, vellum, or pigskin.

The gold used on German bindings of all periods is curiously inferior. It has often changed colour completely, and is now quite

black; at other times it has a strong coppery tinge, and again is very pale. The decorators of these books trusted to the fine impressions on the leather to impart distinction and beauty to their work, and in many cases they were fully justified.

Several German bindings bear portraits of personages connected more or less closely with the Augsburg Confession, proclaimed at Augsburg in 1530 by John, Elector of Saxony, whose portrait occurs in gold on a copy of the Confession itself, surrounded by small stamps in blind of Moses, St. Paul, the Agnus Dei, &c. The portrait of another strong adherent of the "Confessio des Glaubens," Graf Churfurst Friedrich Pfalz, adorns another binding, dated 1561. He is surrounded by a roll stamp on which are portraits of Erasmus, Martin Luther, Philip Melanchthon, and John Hus, some of them bearing the dates 1554 and 1559. Besides the roll are other rather larger stamps with representations of David with a harp, St. Paul, the Ancient of Days, and allegorical figures of Hope, Prudence, Faith, and Justice. This Churfurst Friedrich was an important person. He promulgated a "Confession of Faith" of his own, and took part in the election of the Emperor Maximilian II., who afterwards summoned him before him to justify some of his religious opinions.

Certainly one of the finest panel stamps used on German bindings is one of the Emperor Charles V. The emperor is in full armour, with a sword in his right hand and an orb in his left. His helmet is by his side. Above his head are the arms of Germany, and in the corners the Arms of Aragon, Aragon-Sicily, and Spain, of which countries Charles was king. On the columns on each side of him winds a ribbon, with the words "Plus ultra Carol Quint," and beneath, in a long-shaped panel, the inscription, "Carole, mortales dubitant Homo Sisne Deusve. Sunt tua sceptrum hominis sed tua facta Dei." The engraving of this panel is wonderfully fine, it is like a beautiful medal in leather.

Charles resigned his crown in 1556, and in 1557 he became a monk in the monastery of St. Just in Estremadura, his chief amusement being to try to make two clocks of his own workmanship keep perfect time together. On books ornamented with this stamp, an equally fine one, probably cut by the same artist, of John Frederick II., Duke of Saxony, occurs on the other side.

Luther and Melanchthon have perhaps been more represented on bookbindings than any

other persons. Portraits of them, of all sizes, from full length to very small roll stamps, are commonly found, sometimes in gold, but usually plain, and very frequently with dates added;

FIG. 5.



German binding in pigskin with panel stamps in blind of Martin Luther and Melanchthon. Dated. *British Museum.*

the stamps themselves are not of particularly good workmanship, and they are impressed both on calf and pigskin. A very fine panel stamp exists of Maximilian II., Emperor of Germany, who died in 1576. This stamp, as far as I know, is always on vellum or pigskin. The emperor is crowned, and is in royal robes, over armour. He carries a sceptre in his right hand, and an orb in his left, and round his neck the jewel of the Order of the Golden Fleece. At the top are two escutcheons, one bearing the double-headed eagle of Germany, the other the arms of Spain quartered with Sicily. Beneath, in an oblong panel, are the words, "MAXIMILIANVS II. D.G. ROM. IMP. SEM. AVGVS. GERMA. HVNGA. BOHEMI. ETC. REX. ARCHID. AVSTRI. DVX SILESIE."

Besides these great people, there are hosts of others represented in a similar kind of way, from simple preachers like "Primus Truber Carnio," to grandees like Louis the Pious, Duke of Württemberg, with very often on the other side elaborate coats of arms with many quarterings and many crests.

Some of the 16th century German bindings have chains attached to them; no doubt they were chained to the shelves or desks on or in which they were kept. Others, again, have long projecting tags of leather, with a button at the end to fasten to a belt.

Bindings in metal were made to a considerable extent in Germany, some of fine workmanship. An especially good example covers a copy of Bassiere's "*Flosculi Historiarum*," now in the British Museum. On each side is a delicate panel of filagree silver work, over gilt, having in the centre an elon-

gated silver oval with niello designs upon it in dark grey. The borders are also ornamented with niello. This binding is probably 16th century work, earlier than the work it now covers. A fine 17th century example of pierced and engraved metal work, with a curiously jointed double back, is a copy of Ortel's "*Frauenzimmer Spiegel*." It is gilt, over satin, and has flat metal caps over the inner edges of the leaves at the head and tail of the book.

In the 18th century many bindings in silver, much alloyed, were made in Germany. They are usually repoussé, or stamped up in a more or less artistic manner, and often have portraits of eminent personages upon them. They are best when only arabesque or floral designs are on them, and are much like Dutch work—indeed, it is often difficult to say whether they are really Dutch or German.

At all times there are many names of German binders upon the bindings themselves. These names are generally upon a short ribbon. The best known among them are perhaps John Sulczpach, Johannes Hagmeyer, Ambrose Keller, and Johannes Vogel, all early binders. Besides these full names are many initials. Later Dutch bindings are often ornamented with water-colour silver paint in addition to the gold tooling.

The Dutch imitated, with marked success, most of the well-known styles of binding. Magnus and Poncyn, both of Amsterdam, are amongst the best imitators of Le Gascon. The English embroidered books have been more copied by the Dutch than any other nation. Many of the edges of Dutch books are very

FIG. 6.



Dutch binding in tortoiseshell with silver mounts. Jewish prayers. Amsterdam. 1667. *British Museum.*

elaborately painted. In Holland, however, one style seems to have been invented, namely, the very decorative bindings in tortoiseshell, or, as it should be called, turtleshell. They

are usually strengthened with metal clasps and corners, and if in good condition are very decorative (Fig. 6). In Spain also tortoiseshell was used with fine effect, the metal work being of a finer kind than the Dutch. Little is known in this country about Spanish bindings. Those that are to be found in our great libraries are usually heraldic and decorative, and of good design and workmanship. The same may be said of Portuguese bindings. In the East, in comparatively recent times, an interesting kind of work was invented, probably originating in Persia somewhere about the beginning of the 16th century. These bindings are of paper boards, covered with some kind of white paste, on which are paintings of more or less delicacy, which were, when finished, varnished thickly with a yellowish glaze. Some of the earliest of these Persian bindings are of great delicacy and beauty, often representing hunting scenes, but, through the excessive darkening of the varnish upon them, they are almost impossible to see, and, as far as I have found, quite impossible to photograph. The style was quickly taken up in India, and bindings of this kind are common enough, varying, however, from the simplest arabesque borders only, to most elaborate battle scenes. One I show on the screen represents the Battle of Karnul, with innumerable soldiers, elephants, cavalry, camel corps, and portraits of Nadir Shah and Mohammad Shah. The binding measures 2 feet by $1\frac{1}{2}$ foot, and covers a manuscript history of the Mohammedan dynasties in the East.

LANTERN SLIDES SHOWN AT THE SECOND LECTURE.

Italian.

1. Gold tooled and blind stamped binding in calf, with Arabic designs and letters. Virgilius. Opera. Venetian (?). c. 1500.
2. Red morocco Florentine binding, gold tooled and blind stamped, with cameo portraits of Alexander the Great and Philip of Macedon in sunk circles, with plaited leather clasps. Greek Anthology. c. 1500.
3. Cameo binding in morocco, with designs of Horatius Cocles and Curtius; hand coloured. Celsus. De Medicina. Belonged to Jean Grolier. Venice. c. 1500.
4. Blue morocco binding made for Tommaso Maioli, with inlay of citron; gold tooled. Hypnerotomachia Polyphili. Venice. c. 1500.
5. Venetian binding in dark blue morocco, richly gold tooled with leaves and Arabic knots. Petrarch. Canzoni. Venice. 1501.

6. Florentine binding in brown morocco, blind tooled, and with cameo portrait of Julius Cæsar in sunk circle. Bonini Enchiridion. 1514.
7. Florentine binding in dark olive morocco, with rich gold tooling and blind lines. Cæsar's Commentaries. 1514.
8. Binding in calf, with gold tooling and blind lines; made for Jean Grolier. Witichind. Saxonis rerum libri. Basilæ. 1532.
9. Binding in dark olive morocco, gold tooled (belonged to Demetrio Canevari, physician to Pope Urban VII.), with cameo stamps of Apollo driving a chariot; coloured by hand. Polydorus Vergilius de Hist. Anglica. Basilæ. 1534.
10. Venetian binding, with sunk panels in the oriental fashion, partly stamped in gold and partly coloured by hand. A presentation book to Queen Elizabeth, with her arms and name. Mascher. Il fiore della Retorica. 1560.
11. Binding with the arms of the Foscarini family in gold. Quirino. Curso delle ragione della Repubblica di Venetia. Venice. 1606.
12. Italian binding in red morocco, with fine gold tooling and fan-shaped corners; small inlays of coloured leathers. Ripamonti. Hist. Patriæ Mediolani. 1641.
13. Binding in red morocco made for Pope Clement XI., with his arms in gold. Michel. Confutatio libri, &c. Landishuti. 1719.
14. Binding in red morocco made for Henry Benedict, Cardinal York, with his arms in gold. Stellato. In Fidei controversiis Interrogatio, &c. Viennæ. 1752.

French.

15. Binding in calf with perpendicular lines of small tooling in gold and blind. Presented to Henry VIII., with his arms coloured by hand. Galen. Methodus Medendi. Paris. 1519.
16. Calf binding made for Francis I., gold tooled, with his arms, initials, and device of a salamander. Suetonius Tranquillus. XII. Cæsares. Venice. 1521.
17. Binding in brown calf, supposed to be by Geoffrey Tory, gold tooled, with his mark of a broken pitcher. Petrarca. Opera. Vinegia. 1525.
18. Binding made for Jean Grolier; gold tooled in arabesques and with fillets coloured red and green. Macchiavelli. Il Principe. Vinegia. 1540.
19. Binding in pale brown morocco, made for Diane de Poitiers, Duchesse de Valentinois; gold tooled, with some white colour. Moschopuli de ratione exam. orationes libellus. Lutetiae. 1545.
20. Calf binding, with gold tooled arabesques and fillets freely coloured in white, red, green, and blue. Horæ in laudem Virginis Mariæ. Paris. 1549.

21. Calf binding made for Henry II. of France. In the centre is a gold medallion portrait of the king, gold tooled, with arabesques and fillets freely coloured in white, pink, and green. *Costumes du Bailliage de Sens. Sens. 1556.*
 22. Olive morocco binding made for Katharine de Medici, with her arms painted by hand in the centre; gold tooled, with arabesques and fillets richly coloured by hand. *Dionysius Areopagitæ. Opera. Paris. 1561.*
 23. Binding credited to Clovis Eve. Made for Marguerite de Valois, with her arms elaborately gold tooled on red morocco. *Cæsar. Comment, libri. Paris. 1564.*
 24. Binding by Nicholas Eve in orange morocco (one of 42 copies made by him for Henry III. of France), with the royal arms of France and Poland; semis of fleurs de lys and flames; gold tooled. *Le Livre des Statuts de l'ordre du Saint Esprit, &c. Paris. 1578.*
 25. Binding in red morocco made for Henry IV. of France, with the arms of France and Navarre; gold tooled. *De Thou. Historia mei temporis, &c. Paris. 1604.*
 26. Binding by Le Gascon; red morocco, with compartments inlaid in olive and citron; elaborately gold tooled in the pointillé manner. *Chacon. Hist. Belli Dacici, &c. Romæ. 1616.*
 27. Binding made for the historian, J. A. De Thou, with his arms impaled with those of his second wife, Gasparde de la Chastre. The leather has been stamped with a patera before being put on the book; gold tooled. *Phædrus. Fab. Æsopiarum libri. Paris. 1617.*
 28. Small binding by Le Gascon on red morocco, beautifully tooled in gold in the pointillé manner. *New Testament in Greek. Amsterdam. 1633.*
 29. Mosaic binding by Padeloup le jeune; yellow morocco, with inlays of red and dark green; gold tooled; small geometrical design repeated all over each board. *Longus. Daphnis et Chloe. Paris. 1718.*
 30. Mosaic bindings by Le Monnier; red morocco, with coloured inlays of floral design; gold tooled. *Bible. Cologne. 1736.*
 31. "Dentelle à Poiseau" binding in blue morocco; gold tooled. By Derome le jeune. *Pulci. Morgante Maggiore. Venetia. 1546, but bound about 1770.*
- German.*
32. Binding by Jean Richenbach, dated 1475; pigskin; blind tooled, with colour. *Jac. de Voragine. Tabula Festivitatum, &c.*
 33. Cut and stamped calf binding; design of monk at reading desk. *Rainerus de Pisa. Pantheologia. Basle. c. 1500.*
 34. Calf binding, with gold stamped portrait of John, Elector of Saxony, with blind stamped roll having small panels with portraits—Moses, St. Paul, &c. Augsburg confession. *Wittenburg. 1531.*
 35. Calf binding, with gold stamped portrait of Graf Churfurst Friedrich Pfalz, and date 1501, with blind stamped roll bearing portraits of Erasmus, Martin Luther, Melancthon, and John Hus; and others of David, St. Paul, Hope, Prudence, &c. *Bullinger. De origine erroris, &c.*
 36. Gold tooled calf binding, dated 1565, with portraits of Primus Truber, Consul Histranus, and Antonius Dalmata. *New Testament in Crobatisch. Tübingen. 1563.*
 37. Blind stamped binding, with date 1570 in gold; large panel portraits finely cut on each side. On the upper board is a portrait of Charles V., Emperor of Germany, with the arms of Germany and Spain and his badge of double columns, on which is a ribbon with the words, "Plus ultra Carol' Quint;" on the lower board is a portrait of John Frederick II., Duke of Saxony. *Christian Catechism. Lipsiæ. c. 1570.*
 38. Vellum binding, with panel bust stamps of Luther and Melancthon in blind, dated 1578. *Theological tracts of the 16th century.*
 39. Pigskin binding, finely ornamented in blind with arabesque borders, and having in the centre a beautifully cut portrait of the Emperor Maximilian II. in armour, with crown, orb, and sceptre. *Nürnbergische Cronica. 1592.*
 40. Pigskin binding, ornamented with arabesques in blind; in the centre an oval with portrait of Louis the Pious, Duke of Württemberg, on the other side his coat of arms. *Aristotle. Franc. 1592.*
 41. Silver binding, with niello work and filagree over-gilt; earlier work than the book it covers. *Bassieres. Flosculi Historiarum. Col. Agripp. 1688.*
 42. Silver binding, highly repoussé arabesques enclosing oval portraits of Frederick III., Elector of Brandenburg, afterwards Frederick I. of Prussia, his wife, Sophia Charlotte, and others. *Castelli. Il Pastor Infido. 18th century.*
- Dutch.*
43. Red velvet richly embroidered in gold threads, with the arms of James I. of England; sprays of roses and thistles in the corners. *Acta Synodalis Nationalis Dordrechtii Habitæ. Leyden. 1620.*
 44. Tortoiseshell binding, with silver centrepiece, clasps, and corners. *Jewish Prayers. Amsterdam. 1667.*
- Spanish.*
45. Spanish binding in calf, gold tooled, with arms of Philip II. of Spain. *Guntherus Cisterciensis. De gestis Imp. Cæs. Friderici Primi, &c. Augsburg. 1507.*

Portuguese.

46. Portuguese binding in black calf, gold tooled, with floral arabesque. Ximenes. Libro dela Restauracion del hombre. Lisboa. 1608.

Miscellaneous.

MINES AND QUARRIES.

Dr. C. Le Neve Foster's general report and statistics for the year 1897, relating to the mines and quarries in the United Kingdom, has been issued as a Parliamentary Blue-book. It appears that the total number of persons employed at all the mines under the Quarries Act in the United Kingdom and the Isle of Man, during the year 1897, was 852,083, of whom 728,713 were employed in or about mines, and 123,370 in or about quarries. Of the 728,713 persons employed at mines, 578,226 worked below ground, and 150,487 above ground, and of the latter 5,074 were females. Compared with the previous year, there was an increase of 1,901 males working below ground, and an increase of 1,049 males, and a decrease of 40 females working above ground, making a net increase of 2,910 persons. During the two previous years, a considerable diminution had to be recorded. The number of females working at mines is decreasing gradually. At collieries their work consists principally in "banking the tubs," or drawing mine waggons from the cages, running these waggons to the weighing machines, screens, and tips, greasing the waggons, cleaning the safety lamps, picking out any waste rock from the coal, or separating ironstone from shale, attending to offices, and acting as messengers. In the case of ore mines, they are employed for picking, breaking with hammers, and attending to ore-washing machinery and appliances. The work is stated to be healthy in all cases.

Accidents.—It is stated that there were 1,015 separate fatal accidents in and about all the mines and quarries, more than 20 feet deep, in the United Kingdom, involving the loss of 1,102 lives, showing, on comparison with the previous year, an increase of 11 in the number of accidents and a decrease of 86 in the number of lives lost. Eight hundred and ninety-seven of these accidents, involving the loss of 979 lives, occurred in collieries, and 118, involving the loss of 123 lives, in quarries. With one exception no accident in mines caused more than ten deaths, while in 1896 the death roll was swollen by three great disasters. Dr. Foster draws attention to the fact that the decrease in the death-rates mentioned in the two previous reports continues, and that those for 1897 are, in fact, the lowest hitherto recorded. So far as explosions of fire damp or coal dust are concerned, the year 1897 is described as an "annus mirabilis," for the deaths by accidents from explosions

formed a smaller proportion of the total number of fatalities than in any previously recorded year, the exact proportion being only 1·9 per cent. An examination of the causes of these accidents brings to light two striking facts—first, that most of them were due to open flame, either of naked lights, of matches, or of safety lamps illegally opened; and, second, that not a single fatal ignition of gas or coal dust can with certainty be ascribed to the flame of an explosive in shot-firing. Falls of ground, on the other hand, were responsible for 490 deaths. Dr. Foster suggests that by a more liberal use of props, many of the fatalities might have been avoided. The roof, he says, should be supported systematically, the maximum interval between two props being laid down by special rules. He calls attention again to the fact that the German Government have appointed a commission to inquire into the question of accidents from falls of ground, and expresses an emphatic opinion that good must necessarily come from a similar inquiry in this country. In spite of the increased number of persons using shafts, the list of the shaft fatalities is smaller than it was in 1896. The number was only 49, as against 68, or only 6 per cent. of the total number of fatalities. A lamentable increase is recorded in the number of miscellaneous fatal accidents underground—an increase from 235 in 1896 to 307—the percentage to the total being no less than 31·4; but a satisfactory diminution in the number of fatal accidents on the surface—103 as against 129 in 1896—is shown.

Prosecutions.—During the year 107 prosecutions of owners, managers, &c., for offences under the Mines Acts, were instituted, and convictions were obtained in 88 cases, while proceedings were taken in 521 cases against workmen, in 506 of which the offenders were convicted. In no less than 93 cases, men were found contravening the rules about matches and smoking, and there were 49 breaches of the rules concerning explosives.

COD AND LOBSTER HATCHING IN THE UNITED STATES.

In the latter half of 1895, a new fish hatchery, under the direction of the United States Fish Commission, was established at a small place called Ten Pound Island in Massachusetts Bay, and in the autumn of 1897 there were hatched and "planted" in the waters of the bay over 60,000,000 small cod fry. At the end of the year some 30,000,000 eggs were still in process of hatching. The number of eggs successfully hatched is much greater in the early than in the latter half of the season, when only 54 per cent. of the eggs are successfully hatched in proportion to the first half. Sir D. Colnaghi, H.M. Consul at Boston, says that men proficient in stripping a codfish of its spawn are put on board the shore fishing boats which land their catch at Kittery,

Maine, in the proportion of one man to each boat. As the fish are taken alive from the water, they are inspected and, if suitable for the purpose, are stripped of their eggs, which are placed in jars and forwarded to Gloucester, Massachusetts. More or less, the eggs are injured in transit, but it has been, on the whole, advantageous to forward them to Ten Pound Island, where good results in hatching have been obtained. Nature is followed as far as possible in the hatching process, the eggs being placed in perforated boxes and sea water direct from the ocean being continuously pumped through the boxes, so that the temperature may be as nearly as possible the same as that of the ocean. As soon as the eggs are hatched, the small fish are planted or released in the waters of Massachusetts Bay and have to rely on themselves, the same as the fry spawned in the open ocean. Ipswich Bay, Massachusetts, and the contiguous waters appear to be a favourite spawning ground for codfish, and the artificially-hatched fry, therefore, mingle with the many others of their kind and take the same chances in the struggle for existence. There are, of course, no data on which to base any calculation as to the per-centage of artificially-hatched fry which reach maturity, but the officers of the Fish Commission claim that the fish released by them are harder in proportion, the weaker ones having been sifted and the stronger alone planted. As regards the success of the hatchery, it is proved that since the Fish Commission commenced operations the supply has certainly increased. Some years ago so few codfish were taken by the shore fishermen, that the fishery had become unremunerative, but at the present time fish are fairly abundant, and the fishery gives employment to a good number of men, who themselves admit that the hatchery operations have been successful. After the codfish season is over, the officials turn their attention to lobster hatching, and the same operations are gone through as with the codfish. It is said that for some occult reason the lobster fishermen regard this work with indifference, and that although good prices are offered for seed lobsters, they are too often boiled and sold in defiance of the law. Great interest is taken by pisciculturists in the artificial propagation of the lobster, but it is feared that unless a law similar to that in Nova Scotia, which provides for a close season, is passed, the work will be useless.

Obituary.

Dr. JOHN HOPKINSON, F.R.S.—The sad Alpine accident at the Petite Dent de Veisivi, on Saturday, 27th August, which caused the death of Dr. Hopkinson and of his son and two daughters, has deprived the Society of Arts of a most distinguished member. This terrible disaster cut short the valuable life of one of the most eminent scientific men of the day at the comparatively early age of 49 years. Dr.

Hopkinson was the eldest son of Alderman Hopkinson, an ex-Mayor of Manchester, and he was born in that city in 1849. He was educated at Lindow-grove School and Queenwood and Owen's Colleges. After remaining two and a half years at the latter place, he went to Trinity College, Cambridge. In 1871 he was Senior Wrangler and first Smith's prizeman, and he subsequently obtained the degree of D.Sc. from the University of London. In 1872 he became engineer to Messrs. Chance and Company at Birmingham, and he introduced many improvements into lighthouse apparatus. He subsequently removed to London, and practised as an electrical engineer. In 1890 he was President of the Institution of Electrical Engineers; he was also Professor of Electrical Engineering at King's College, London. The list of his papers read before the Royal Society and other scientific institutions is a long one. Dr. Hopkinson was elected a member of the Society of Arts in 1882, and on November 22 of that year he read a paper, "Ice-making and Refrigerating." He was also one of the Society's judges at the tests for motors for electric lighting in 1889.

General Notes.

SCHOOL OF ART WOOD-CARVING.—This school, which has hitherto been held in the Central Technical College, South Kensington, has now been removed to the Imperial Institute, in which rooms have been granted for its use and in which it will be re-opened after the usual summer vacation on Monday, the 5th September. Free studentships in both the day and evening classes of the school are maintained by means of funds supplied by the City and Guilds Institute for the Advancement of Technical Education and by the Drapers' Company. Some of these studentships are at present vacant, and forms of application for them, also information as to the school generally, may be obtained by letter addressed to the Manager, School of Art Wood-carving, Imperial Institute, London, S.W.

COLLEGE OF COMMERCE.—A special committee appointed by the Board of Regents of the University of California, to inquire into the advisability of establishing a college of commerce in connection with the University, reported in favour of the undertaking early this year, and the proposal has been adopted without a dissenting voice. The president of the University has been directed to make application to the President of the United States to the effect that an engineer of the regular army may be detailed to act as instructor in steam engineering and marine transportation. It was the expressed judgment of the regents that the college would expand, and that, among other things, iron shipbuilding and the training of students for a consular career should be taught. This information is given by Her Majesty's Acting Consul-General at San Francisco, in a report to the Foreign-office.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.

DETERIORATION OF PAPER.

The Report of the Committee of the Society of Arts on the Deterioration of Paper has now been published, price 1s., and can be obtained on application to the Secretary, Society of Arts, John-street, Adelphi, W.C. Two Appendixes are printed with the Report:—1. Abstracts of Papers on German Official Tests, 1885-96; 2. Précis of Correspondence.

Proceedings of the Society.

CANTOR LECTURES.

DECORATIVE BOOKBINDING.

BY CYRIL DAVENPORT.

Lecture III.—Delivered February 7, 1898.

ENGLISH BOOKBINDING FROM THE 16TH CENTURY TO THE 18TH CENTURY INCLUSIVE.

The commoner English bookbindings of the early 16th century were usually ornamented with impressions, in blind, from large panel stamps, many of which appear to have been of Netherlandish origin. They are largely heraldic, but several of them are illustrative of Biblical subjects or incidents in the lives of saints.

The coat of arms of Henry VIII. with Tudor emblems is commonly found (Fig. 1), as is also the coat of Katherine of Arragon, and more rarely that of Anne Boleyn. These coats are generally upheld by two winged angels. On some of the bindings by John Reynes is a curious coat of arms of Jesus Christ (Fig. 2), and on several of them

occurs a stamp bearing a large Tudor rose as a central ornament with a ribbon enclosing it, on which are the words, "Hec Rosa Virtutis de cœlo missa sereno Æternum florens regia sceptrâ feret." In the upper corners of this design are the coats of arms of St. George and that of the City of London, so it is supposed that the binder who used it was a freeman of the City of London. The initials of the binder often occur in the lower part of the panel. "I.N." probably stands for Julian Notary; "R.L." for Richard Lant; and so on, the binders often being the same as the

FIG. 1.



English panel blind stamped binding in calf, with arms and badges of Henry VIII. Collection of 16th century tracts. British Museum.

printers. Although Royal coats occur on several of these bindings, it is not at all certain that the books were ever Royal property, and they should not be considered so unless their known history confirms such an attribution.

An early official note concerning an English bookbinder occurs in a patent of Henry VIII., dated 22nd February, 1530, making Thomas Berthelet the king's printer. This Thomas Berthelet also bound the Royal books, and was the first English binder to use gold tooling on leather. A bill of his for such work still exists, in which he describes the bindings as

being "after the Italian fascion" (Fig. 3), "in crymosyn satin," or "covered with black

FIG. 2.



English panel, blind stamped binding in calf. By John Keynes. The design is a coat of arms with emblems of the Passion, &c. *Psalterium Cisterciensis ordinis*. c. 1525. *British Museum*.

FIG. 3.



English gold-tooled binding in doe-skin, by Thomas Berthelet for Henry VIII. Elyot. *The Image of Governance*. London, 1541. *British Museum*.

velvet." The note about the "Italian fascion," of course, alludes to the fact that many of

Berthelet's early bindings are finished with gold tooling made by means of stamps cut in imitation of several of those used on 15th century Italian bindings.

It is indeed often difficult to distinguish between an early English gold tooled binding and an Italian one, but there is one peculiarity about Berthelet's work even when it is most like the Italian originals, and it is that he nearly always used a black dye on the fillets with which these bindings are generally decorated. The black has in many cases worn off, but as it was made by means of some weak acid, the surface of the calf—in which leather the majority of Berthelet's bindings are—is usually eaten away to some extent, and the fact that the stain was originally there can be easily recognised. The Italian bindings on which these are modelled do not have these black fillets.

Berthelet bound books for Henry VIII., Edward VI., and Mary; and besides the calf already mentioned, he used freely white deer skin and vellum—as far as I know, he never used morocco, or, as it would then have been called, goat skin. As to the books recorded by him as having been bound in satin and velvet, there are no data by which they can be identified, but as each of the three sovereigns for whom Berthelet worked have left us specimens of bindings made for them in these materials, it is likely enough that some of them are really Berthelet's work. Because, however, of the utter difference in workmanship between the adornment of a satin or velvet binding as compared with one in leather, we cannot say certainly that, because in the satin and velvet books of the early 16th century Royal English book we find no design that resembles Berthelet's stamps, they are not his.

The edges of valuable books were decorated with paintings and gildings of various kinds from a very early period, and Berthelet fully appreciated the value and beauty of this addition to the ornamentation of fine bindings. The particular manner in which he usually dealt with the edges of his books was to have them slightly tinted with some pale yellow pigment, and on this to write in gold the inscription, "Rex in Æternum vive." After these words occur, in many instances, the curious word "Nez" or "Neez." Among the several interpretations of this word that I have heard, one of the best is, I think, that of Mr. J. L. Scott, of the Department of Manuscripts in the British Museum. Mr. Scott thinks it may refer to Nebuchadnezzar. In

the Book of Daniel these words are addressed to this king, *Ναβουχοδονόσωρ ἑσραὲλ ζῆθι*, and the initial letters of these words make "Nez." The strong probability is that when this inscription is found on the edges of a book that belonged to Henry VIII., that it was bound by Thomas Berthelet, the first great English bookbinder whose name is known to us. Berthelet sometimes finished his books with some reference to their subject, one of his on "Geometry" being decorated outside with triangles, &c.

The English binders were not allowed to have a very peaceful time for long, as in 1553 the influx of foreign workmen was so hardly felt that an Act was passed for the special protection of English printers and binders, and it was made unlawful for anyone to buy or sell any book ready bound from abroad; and among the registers of the Stationers' Company may be found several other petitions against the foreign workmen. Among these registers are many curious and interesting items about bookbinders, their apprentices, and their methods, all of which are very carefully laid down; indeed, some of the rules seem too stringent. For instance, in one dated "xxv. March, 1586," it is laid down that "in the volume called folio there maie be bound styched onlie ffortie sheetes and not above. In the volume called octavo twelve sheetes onlie and not above;" and, further, on the same register it is ordered that no bookseller "shall putt any woorke to be bounde, unto or by any fforayner, stranger, or to any person whatsoever that are not freeman of this citie." Of course the foreigners—chiefly Frenchmen—became freemen "of this citie," and so, in due time, became practically English themselves; and it is very likely due to the taste and skill introduced by these no doubt excellent craftsmen that we owe much of the delicate workmanship that we find all along in English gold tooled work. The ordinary processes of binding a book, although they are undoubtedly skilled labour, are such as any man with manipulative skill can easily learn, but the art of gold tooling on the finished leather is a very different matter, and to be well done requires most delicate care and knowledge, and the utmost skill and steadiness of hand. This art the French have certainly excelled in even up to the present day. So that possibly we must not regret too much that the highly skilled French workmen came over and brought some of their careful finish, to the enhancement of the good sewing and forwarding that

they doubtless found here from very early times.

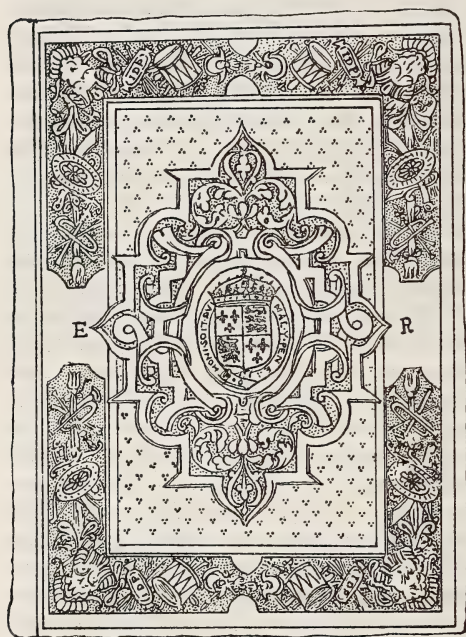
Henry VIII. and Elizabeth possessed several small books bound in gold, some of which still exist. They were generally enamelled as well, some of them being very fine specimens of such work. Such books must have been always of great value, and therefore they never became common; but no doubt there were many more of them than we have now left, as mention exists of such presents having been given to Queen Elizabeth's maids of honour. Some of these are still in private hands, but others can be seen at the British Museum, both in the Departments of Manuscripts and Printed Books. But in fact, during all the Tudor period very decorative bindings were made in England. Berthelet set the fashion, and he, like all great masters, had imitators. More than that, his example encouraged others to strike out lines for themselves. Few names of binders at this time are known. It is supposed that John Day, a printer, bound some of the books that belonged to Queen Elizabeth. These are generally bound in calf, with black fillets imitated from Berthelet, but charmingly ornamented as well with real inlays of white vellum, on which are gold impressions from large blocks. The letters "I.D.P." occur on some of these blocks, and it is supposed that they mean "John Day Printer." (Fig. 4.) I think these stamps have more of a foreign character than English, but it is possible enough that John Day had them cut for him by a foreign workman. The bindings are bold and excellent in design, usually bearing in the centre the Royal coat of arms, the field being covered with what the French call a "semis" of triple dots. Some of Elizabeth's books have also a "semis" of roses. It is certain that Matthew Parker, Archbishop of Canterbury, employed bookbinders to bind the books he had printed at his private press at Lambeth. It is not now positively known if any of these bindings still exist, but it is very likely that the copy of his book, "*De Antiquitate Britannicæ Ecclesiæ*," printed in 1572, which the archbishop is supposed to have presented to Queen Elizabeth, was bound under his direct auspices. It is bound in green velvet beautifully embroidered, the design being a park, within which are deer and roses, being, in fact, a play upon the word "Parker."

The most noteworthy collectors of this 16th century, as distinct from the binders, whose names and work are known, not counting the

sovereigns who have invariably, from the time of Henry VII., been most constant and appreciative lovers of fine bindings, were Henry FitzAlan, Earl of Arundel, Thomas Wotton, and Robert Dudley, Earl of Leicester.

Henry FitzAlan took advantage of the suppression of the monasteries in the earlier part of the century and acquired, in consequence, several valuable works which otherwise would never have left the security of the religious walls. Besides these priceless treasures, he also acquired many of the books that had belonged to Archbishop Cranmer, a large

FIG. 4.



English gold-tooled binding in calf, inlaid with vellum. Belonged to Queen Elizabeth, and was probably bound by John Day. Gospels in Anglo-Saxon. London, 1571. *British Museum.*

number of which bear his signature. The whole of the FitzAlan library was bequeathed to his son-in-law, Lord Lumley, who was afterwards tutor to Henry Prince of Wales, and by this prince it was purchased in 1609. There seems little doubt that Henry FitzAlan had taste in bindings, the very few instances left as they were in his time being of considerable beauty, and bearing as a central ornament the Arundel badge of a white horse "courant" with a spring of oak in its mouth. On one beautiful specimen this horse is represented by a little cameo of white leather inlaid on calf, the date of the printing being 1544, that of

the binding probably about the same. Lord Lumley generally signed his books, but beyond this he does not appear to have changed them to suit his own fancy; but their next owner, the Prince of Wales, did so very largely—indeed, he rebound almost every book in calf bindings heraldically decorated. The best known of these bindings have in the centre the Royal coat of arms with the silver label of the eldest son, and in the corners either the ostrich plumes, crowned roses, lions, or fleur de lys, designed too largely for good taste. These are always stamped in gold, except the ostrich plumes, which are in silver. The books bearing these stamps are perhaps of the greatest general interest of any old Royal English bindings, because they are sometimes to be met with outside the large Royal libraries, some of them, at some period of their history, having been allowed to leave the remainder and get into the open market. Besides these, Prince Henry had others bound which have the Prince of Wales's plumes as a centre ornament; many of these are excellent in taste and pleasing in colour, the smaller ones especially. We owe a great debt of thanks to Prince Henry, because he brought together at St. James's Palace all the old books that he could get hold of that had belonged to his Royal predecessors, and by his appreciation of them and the additions he made, not only by the accession of the libraries just mentioned of the Earl of Arundel and Lord Lumley, but also by that of Isaac Casaubon and a Welshman named Maurice, he actually laid the foundation of the Royal library of England, which was ultimately presented to the nation by George II., in 1757, and has been preserved ever since in the British Museum.

Thomas Wotton, the father of a well-known writer, Sir Henry Wotton, was also a celebrated collector of books who had his volumes bound for him in a particular way. He died in 1587. His bindings are always in brown calf, tooled in gold with black fillets, after the style used by Thomas Berthelet. Some of them have a small coat of arms impressed in silver as a centre ornament, and many of them bear the words, "THOMÆ WOTTONI ET AMICORVM," on them, being almost the same words as were used by Jean Grolier, Treasurer of France, at an earlier date. In consequence of the occurrence of this motto, as well as some distant similarity in the style of some of the designs used by both collectors, Wotton is known as the "English Grolier."

The decorative badge of the bear and the ragged staff, used by the family of Dudley, Earls of Leicester, is often found on books that belonged to Robert Dudley. The initials R.D. are often combined with the badge, which is stamped variously in gold, in silver, and in silver and gold. The remaining gold tooling on several of these books is very well designed and decorative. Although the semis, or powdering, of various small kinds over the ground of binding designs occurs in English bindings made for Queen Elizabeth, the idea is considered to be French originally. In England the method of decorating the larger part of a book with a symmetrical repetition of small stamps did not come into any general use until the reign of James I., and under this king the semis was largely used. The most usual stamps used for the powderings are lions, thistles, fleur de lys, and roses, and in many instances the effect is very rich. In combination with these are used large corner pieces and usually heraldic centres, and the decorative method of binding books in velvet stamped in gold was also made use of in this reign more than in any other, although it was first thought of in the time of Elizabeth, and was also afterwards done at Little Gidding.

John Gibson was appointed king's binder while James was in Scotland, and there is a list of books bound by him in Dibdin's "Decameron." Unfortunately, not one of these has been identified. There is, however, one binding which is likely enough to have been bound by him. It covers the original manuscript by King James of his ΒΑΣΙΛΙΚΟΝ ΔΑΠΟΝ, written for the benefit of his "dearest son Henry the Prince." The book is very decoratively bound in purple velvet and rarely ornamented with thin plates of gold, engraved with delicate lines. The centre is the ancient coat of Scotland, with the collar and badge of the thistle, unicorn supporters, and motto. Above are the initials I.R., and the clasp plates and corners are conventional thistles and curves. No other book is ornamented in this way. When James came to England John and Abraham Bateman were his binders, and they probably bound most of the books now left of his, but there is no certainty about any one of them.

During the reign of Charles I. the same style of binding generally prevailed as during his predecessor's time—powderings, heraldic ornaments, and large corners; also between 1625 and 1642 were made the curious "Harmonies" of Nicolas Ferrar at Little Gidding.

The finest of these were bound in velvet, tooled in gold or silver, with small stamps of peculiar designs. They were nearly always large books, which in those days was rare. One measures 29 by 20 inches, thereby strongly contrasting with the generality of printed books, which had been small ever since the invention of the typographic art. The decoration on most of the Little Gidding bindings consists of a circular ornament in the centre, and in each corner a quarter of the same. The velvet used is blue, purple, or green, and the leather is always black. These bindings are supposed to have been bound by the nieces of Nicholas Ferrar, under the special direction of Mary Collet, taught by a binder from Cambridge; and they have every appearance of having been made by skilled amateurs not possessing too many shop appliances. But for the encouragement of lady bookbinders, it may safely be said that no more splendid bindings have ever been made than those prepared by Mary Collet for King Charles and his sons. Both for size, magnificence of colour, and richness of decoration they have never yet been excelled. The finest specimens now left are in the possession of the Marquis of Salisbury, the Earl of Normanton, and Captain Gausson.

An interregnum in bookbinding, as in every other fine art, occurred during the civil wars in England, and the Restoration is marked by the work produced by the second great English bookbinder whose work is known.

In June, 1660, the office of "Royal bookbinder" was conferred upon Samuel Mearne, who died in 1683. The finest of his books were bound for the king, as might be expected, and these have always some Royal heraldic mark upon them, often consisting of two interlaced C's crowned, between two palm branches; they are either in red, or dark blue, morocco. Other of his volumes are charmingly tooled in compartments with delicate pointillé fillings, after the style introduced by the great French binder, Le Gascon. Mearne invented what is known as the "Cottage style" of decoration on a book. Books ornamented in this way have the lines of an inner panel amplified at each end, upper and lower, into the outline of a gable roof. The lines composing this gable are usually stained black, following again the lead given by Thomas Berthelet, and the spaces that remain are often very richly filled with festoons and masses of very delicate and beautiful gold tooled work executed with small, very finely cut stamps of peculiar designs.

The simpler books bound by Mearne have

an inner panel outlined in gold with fleurons or other ornamented designs at each corner. The leather he used was the finest morocco, with a smooth surface. The gilt edges of the finer books bound by Samuel Mearne are sometimes ornamented in a remarkable manner. They are painted in water-colours under the gold. This painting was executed when the leaves were fanned out, then, when finished, the gold was applied as usual. The result is that often enough these painted edges have remained unseen for centuries, as they only show when held in a particular way. Mearne was the first binder to use this kind of ornamentation; he was followed in it by his son and successor, Charles, and, after some interval, by James Edwards, of Halifax.

The influence of Samuel Mearne's art was directly felt for a very long time (Fig. 5), and,

FIG. 5.



English gold-tooled binding in morocco. In the style of Samuel Mearne. *Fables of Pilpay*. London, 1639. *British Museum*.

to some extent, remains with us to the present day; and although he founded much of his work on French models, he ultimately developed a style of his own of which we may well feel proud.

The decline in the art of bookbinding which occurred in England from the death of Samuel Mearne until the coming of Roger Payne, about 1770, would have been worse than it was if it had not been for the long continuance of

the styles used by Samuel Mearne. Nearly all the better work done during this time owes what excellence it may possess to his initiative, the cottage style particularly remaining with us, and lending itself to all sorts of modifications and amplifications, many of which are very good.

Among our more original designers must be mentioned Elkanah Settle, a most remarkable man in many ways, eccentric to the last degree. He lived during the latter half of the 17th century, and is known as the "City poet." He wrote poems addressed to various people of note, many of which he presumably bound himself and ornamented with heraldic designs and decorative borders. The leather he used was generally bad sheep's skin, sometimes calf, and the ornamentation is done in gold tooling in a rough and ready manner, the various bearings on the coats of arms, and the small pieces at the corners, being laboriously stamped one by one, colour being added now and then. Although the actual finishing of these books is very faulty, they are not by any means displeasing generally, and I think they are likely to be more appreciated and valued as time goes on; they certainly have a strong personal interest, as each one is made for some particular patron. The binders of Little Gidding and Elkanah Settle are the only instances in the history of English book-binding where amateur work has made any lasting mark.

The trade bindings came much to the front with the skilled work done by, or for, Eliot and Chapman. These binders worked for Robert Harley, Earl of Oxford, in the 18th century, and used ornamental centre pieces and broad borders. Several books are curiously ornamented with small, finely-engraved stamps cut in emblematic designs by Thomas Pingo, the medallist. These books belonged to Thomas Hollis. They are not uncommon; the leather is usually fine, smooth red morocco, the ornamentation is more curious than beautiful, and is best when there is not much of it.

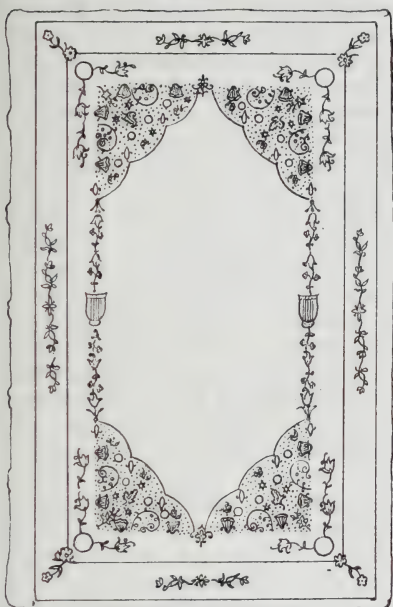
Towards the end of the century, a book-binder of the name of Roger Payne came from Windsor and set up in London. He was at first apprenticed to Osborne, a Holborn book-seller, but somewhere about 1770 he set up for himself. He was very poor all his life, and addicted to drink, but in spite of these drawbacks, his original genius for the ornamentation of books showed itself with such effect that he not only produced some of the very finest English bookbindings existing, but has

had a greater influence on the art in England than any other binder except Le Gascon.

Bookbinding is essentially an imitative art, and Roger Payne undoubtedly studied the best work both of Samuel Mearne and Le Gascon. Many of his smaller stamps are copied from one or other of them; but they are always modified, and the general arrangement of his masses of gold work is quite his own.

Most of Payne's books have large ornamental corners worked with very fine stamps, circles, and dots (Fig. 6), and many of them have

FIG. 6.



English gold-tooled binding in morocco. By Roger Payne about 1790. Greek Anthology. Venice, 1550. *British Museum.*

ornamental doublures, or insides to the boards. His books are usually sewn with silk, and the backs strengthened with supplementary pieces of leather, making them very strong but stiff to open. His favourite leather was smooth or straight-grained morocco, but often he used Russia, an excellent leather to take the impression of the stamps in gold, but a very bad one for lasting. It is said that Roger Payne cut his own stamps—often in iron—and this is likely enough. The gold tooling on most of his books is excellent, bright, and strong, and has most probably been re-gilded several times. He took the greatest interest in each book he bound, and very often added a careful note in his own handwriting saying what he had done to the work, and what stamps he used, many of them being, to some extent, chosen according to the subject.

Payne towards the end of his life (he died in 1797) took Richard Wier to be his partner. Wier drank as well as Payne, but nevertheless he and his wife were the first binders in England to study and practice successfully the difficult art of mending and repairing paper. This is now a very important branch of the binder's profession, and it is one that is likely in the future to be of even more importance than it is at the present moment. When much of the paper used now arrives at the stage when mending is necessary, it will tax all the ingenuity of the chemists and paper-menders to the utmost to repair it in such a manner as to preserve the legibility of the printed matter in a satisfactory manner. Indeed already, in my own experience, the greatest difficulty occurs sometimes in quite modern books, which are much used, in the endeavour to keep them together. It is sincerely to be hoped that the endeavours of the committee which has lately been considering this subject, will have some practical result.

James Edwards, a bookbinder of Halifax, and an artist, who came to London about 1785, invented and patented a curious manner of rendering vellum transparent. He did this by means of pressure and soaking in pearlash, but no doubt there are other ways of producing the same result. He bound his books in white paper, on which he painted delicate designs in water colours, over all these he placed his transparent vellum, which acts as a complete preservative, so that if the vellum is not torn the paintings under it are as fresh as if done yesterday.

Edwards and another binder, John Whitaker, often used what is known as "Etruscan" design on their bindings. The Greek fret and classical vases are the most easily recognised of these. Whitaker used with great effect the darkening effect of a strong solution of soda upon pale calf. He made stencil plates and sprinkled the soda through the spaces as required, or actually painted it upon the leather. Some of his bindings are very delicate in graduated browns, and pleasing in effect. On some of Edwards's finer books the edges are painted in the same way as Samuel Mearne's. Edwards, in all probability, did this work himself, and on his books it is always very delicate and pretty. It was imitated to some extent afterwards, but never very extensively as it is troublesome to execute. It often is found on the edges of small books bound in vellum, where its existence has not been suspected.

The remaining English bookbinders of the 18th century, several of whom went on into the beginning of this century, were nearly all close imitators of Roger Payne, but being better workmen, their productions are more highly finished and more accurately tooled; in the trade, much more admired. At the same time the artistic value, which is so marked in all Roger Payne's work, is wanting in most of the bindings done by Kalthoeber, Charles Lewis, Charles Hering, Walther, and others. Charles Lewis was perhaps the best of these. He bound well and largely for the Right Hon. Thomas Grenville, and his books are most easily known by the peculiarity they usually possess of broad flat bands on the backs. They also often have excellent decorative work inside the boards. These binders used sometimes tickets in their bindings, and sometimes their names gilded in small letters on the leather.

LANTERN SLIDES SHOWN AT THE THIRD LECTURE.

1. Velvet binding, with enamels on silver of the Royal coat of arms and Tudor badge of a Portcullis. Made for Henry VIII. With five silver boxes, each containing an impression of the Great Seal. A copy of the Indentures made between Henry VIII. and John Islippe, Abbot, for the foundation of the chantry at Westminster. c. 1504.
2. Binding in calf, gold tooled, probably by Thomas Berthelet. The Royal arms within a diamond-shaped fillet with decorative border. Galteri Deloeni Libellus de tribus hierarchiis. c. 1510.
3. Golden binding, $3 \times 1\frac{1}{2}$ inches, with remains of black enamel on leaf sprays. Psalms. Belonged to Henry VIII. c. 1520.
4. Green velvet binding, with centrepieces, corners, and clasps of silver, partly gilt, bearing the letters of the names MARGUERITE and ANNA, being those of former owners: Anna, wife of Ferdinand, king of the Romans, and Margaret Tudor. Le Chapelet de Jesus. 16th century.
5. Calf binding, gold tooled, probably by Thomas Berthelet. Belonged to Henry VIII., and has his arms with supporters within an oval, and ornamental corners.
6. Dark calf binding, gold and blind tooled, made for Mary, Duchess of Suffolk, with her arms and initials. Herbarium. Francofurti, 1535.
7. White deerskin binding, probably by Thomas Berthelet, gold tooled. Made for Henry VIII., with his initials and motto. The edges have the words "Rex in Æternum vive Nez," written in gold upon them. Elyot. The Image of Governance. London. 1540.
8. Pale calf binding, gold tooled in arabesque and ribbon pattern. Made for Henry Fitz Alan,

Earl of Arundel, with his badge of a white horse having an oak spray in his mouth. Bible. Venetiis. 1544.

9. Brown calf binding, gold tooled in arabesque and ribbon pattern. Made for Thomas Wotton, with his arms impressed in silver in the centre. Montecrucis. Contra sectam Mahumeticam. Parisiis. 1543.
10. Brown calf binding, gold tooled. Made for Robert Dudley, Earl of Leicester, with his crest of a bear and ragged staff impressed in silver in the centre. Clemens Alexandrinus. Opera. Florentiæ. 1550.
11. Brown calf binding, gold tooled in arabesque and ribbon patterns. Probably by Thomas Berthelet. Made for Edward VI., with his coat of arms and crowned initials. Dated 1552. The ribbons or filets, many of the curves of which are circular, are stained black. The back of this book is made so that it looks like the front. Bembo. Hist. Venetæ, libri xii. Venice. 1551.
12. Scottish binding in black calf, curiously hand tooled in gold, and coloured. Made for Mary Queen of Scots, with her coat of arms and supporters. The Black Acts. Edinburgh. 1556.
13. Calf binding, with double boards, the upper one pierced. In a recessed oval on the upper board is a hand-painted portrait of Queen Elizabeth, to whom the book belonged, and in the lower board a corresponding painting of her coat of arms. Dated 1568. Gold tooled, and elaborately coloured. Bible. Lyons. 1566.
14. Calf binding, with double boards. Gold tooled, and having inlaid vellum corner pieces. In the centre is a recessed oval, and a painting of the coat of arms of Queen Elizabeth, to whom the book belonged, with her initials. Nicolay. Navigationes orientales. Lyon. 1568.
15. Red velvet binding, with gold centre-pieces, corners, and clasps, beautifully enamelled in translucent colours. The designs are generally conventional flowers, but on the centre-pieces is the red Lancastrian rose crowned. Christian Meditations. Lugduni. 1570.
16. Calf binding, inlaid with vellum. Gold tooled. Probably by John Day. With the arms and initials of Queen Elizabeth, for whom it was bound. Gospels in Anglo-Saxon. London. 1571.
17. Green velvet binding, gold stamped and *appliqué*, with coloured pieces of silk. Made for Queen Elizabeth, with her coat of arms and initials. The edges are highly ornamental with gold and painting. Biblia. Tiguri. 1544, but probably bound about 1575.
18. Golden binding, with figures in high relief and enamelled. $2\frac{1}{4}$ by $1\frac{1}{4}$ inches. Belonged to Queen Elizabeth. On one side the Serpent in the Wilderness, on the other the Judgment of Solomon.

19. Scottish binding in purple velvet, with centre-pieces, corner-pieces, clasps, and initials I.R. of pierced and engraved gold. The centre-pieces are the arms of Scotland, and the smaller pieces conventional sprays of thistle. MS. of *ΒΑΣΙΛΙΚΟΝ ΔΩΡΟΝ* written by King James VI. of Scotland. 1599.
20. Blue morocco binding, very elaborately gold tooled in arabesque and dotted ribbon pattern. Made for James I., with his coat of arms, inlaid in coloured leather, and initials. Thevet. *Vies des hommes illustres*. Paris. 1584.
21. Brown calf binding, elaborately gold tooled in leafy design, with heavy corners. Made for James I., whose coat of arms is within a rectangular panel in the centre, partly coloured by hand and partly inlaid. Ortelius. *Theatrum orbis terrarum*. London. 1606.
22. Binding in calf, gold tooled with fleurons and dotted ribbon. Made for Henry Prince of Wales, with his badge of ostrich feathers impressed in silver in the centre. Livius. *Hist. Romana*. Geneva. 1609.
23. Calf binding, gold tooled. Made for Henry Prince of Wales, with his coat of arms in the centre. In the corners are large ostrich plume badges impressed in silver. Adam Goddam. *Super libros sententiarum*. Paris. 1512, but bound about 1610.
24. Red velvet, stamped in gold and silver. Made for Henry Prince of Wales, with his badge of ostrich plumes and coronet. Becano *Baculus Salcolbrigiensis*, &c. Oppenheim. 1611.
25. Vellum binding, gold tooled. Made for James I., with his coat of arms and semis of large and small stars. Robert, Abbot of Salisbury. *De gratia sanctorum*, &c. Londini. 1618.
26. Vellum binding, gold tooled. Made for Prince Charles, with his badge of ostrich feathers, heavy corner-pieces, and semis of flaming hearts. Almanacks. 1624.
27. Black morocco binding, gold tooled. Made for Charles I., with his coat of arms, heavy corner-pieces, broad arabesque border, and semis of roses, thistles, and fleurs-de-lys. Raderus. *Bavaria Pia*, &c. Munich. 1628.
28. Crimson velvet binding, with pierced and engraved centre-pieces of silver. In the centre, on one side, a medallion portrait of Charles I., and on the other, one of Queen Henrietta Maria. New Testament. London. 1643.
29. Red morocco binding, elaborately gold tooled with leaf sprays and arabesques by Samuel Mearne. In the cottage style, the fillets stained black. Made for Charles II., whose crowned monogram is in the centre. Common Prayer. London. 1699.
30. Red morocco binding, elaborately gold tooled with arabesques and leaf sprays by Samuel Mearne. In the cottage style, the fillets stained black. Common Prayer. London. 1678.
31. Red morocco binding, made for William III., with his arms, the three fleurs-de-lys being placed in the fourth quarter. Audley, Earl of Castlehaven. *Memoirs*. London. 1681.
32. Binding in blue morocco, delicately gold tooled in the cottage style with leaf sprays and arabesques. Fables of Pilpay. London. 1699.
33. Red morocco binding with rectangular inlay of black, richly gold tooled with large conventional flowers in outline, and arabesques. Paraphrase on St. Paul's Epistles. London. 1702.
34. Red morocco binding, finely gold tooled with vases and flower sprays. In the cottage style, the fillets stained black. Common Prayer in Dutch. London. 1704.
35. Binding in transparent vellum, with painting underneath it, by James Edwards of Halifax; there are also paintings on the edges of the leaves. Made for Charlotte of Mecklenburgh, Queen of George III., with her arms. Common Prayer. London. 1760.
36. Smooth olive morocco binding, gold tooled, by Roger Payne. Large corner-pieces and arms of C. M. Cracherode, to whom the book belonged. *Erotemata Lascaris*. Venetiis. 1495, but bound about 1770.
37. Red morocco binding, gold tooled. Bound for George I., with his arms and crowned initials. Conference for establishing the succession to the crown, &c. C. 1719.
38. Red morocco binding, with centre arabesque gold tooling in diamond shape, and corners. Bound for George II., whose arms are in the centre. Bishop of Coventry's Defence of Christianity. London. 1728.
39. Scottish binding in blue morocco, gold tooled. The centre panel of long, rectangular shape. Nisbet. *Doctrine of Decimal Arithmetick*. Edinburgh. 1738.
40. Straight grained blue morocco binding, gold tooled, with large corners, by Roger Payne. Shell cameo inserted in centre of upper cover. Virgilius. Works. Venice. 1505, but bound about 1775.
41. Blue morocco binding, delicately gold tooled after the manner of Roger Payne, by Charles Kalthoeber. Bound for George III., whose arms are in the centre. The Mazarine Bible. Bound about 1800.
42. Straight grained red morocco binding, gold tooled after the manner of Roger Payne, by Kalthoeber. Cicero. *Epistolæ ad familiares*. Venice. 1649, but bound about 1810.
43. Orange morocco binding, plain outside with broad flat bands, gold tooled, by Charles Lewis. With inlaid vellum doublure. Bound for the Right Hon. Thomas Grenville, with his arms. Bartholomæus Glanvilla. *De proprietatibus rerum*, &c. Bound about 1830.

Miscellaneous.

INDUSTRIES OF BRITISH INDIA.

The Board of Trade have received, through the India-office, copies of a Report and Tables giving such particulars as are obtainable of certain Indian industries, carried on upon a somewhat extensive scale.

The following particulars, arranged in alphabetical order, are from the *Board of Trade Journal* :—

Bone-crushing Mills.—Seven at Bombay, two in Bengal, one at Madras, one in Malabar, two at Coimbatore, one in South Canara, and two at Karachi.

Cement Works.—Only one cement work is reported, located in Madras.

Coffee Works.—These are reported to be fifty six in number, all in Madras.

Cotton Ginning, Cleaning and Pressing Mills.—There is a great number of these in Madras, Bombay, Sind, Berar, the Central Provinces, Central India and Rajputana, the North-Western Provinces, the Panjab, Bengal, and Burma.

Cotton Spinning and Weaving Establishments not classed as Mills.—Twenty mentioned, nineteen of which are in the Madras Presidency, one in Upper Burma, and several unenumerated in Bengal.

Cutch Factories.—One in Bengal.

Dairy Farms.—Excluding some in Bengal, of which the number has not been stated, thirty of these are returned; six in the North-West Provinces and Oudh, eight in the Panjab, four in Sind, five in Bombay, three in the Central Provinces, and four in Madras. This most useful industry promises to attain important dimensions.

Dye Works.—Seven are entered, all in the Bombay Presidency.

Flour Mills.—There are seventy-two of these, but the statement is defective.

Glass Factory.—One is in operation near Calcutta for the manufacture of glass in accordance with European methods. Another has been established in Ahmadabad, but has not yet commenced work. There are various small glass-making establishments in other places, but when they do not use broken imported glass, they turn out articles of a rough and inferior class, though in some cases artistic in form and colour.

Ice Factories.—These are numerous, but the particulars are incomplete.

Indigo Factories.—There are a great number of these in Bengal and the North-Western Provinces, all owned as private concerns, only three—two in Bengal, and the other in the North-Western Provinces—being managed on the joint-stock principle, with limited liability. Great numbers are now owned and worked by natives, but these are still singly small factories. In the Madras Presidency also there are a great number of indigo factories, mostly small concerns. In the Panjab there are said to be nineteen factories.

Iron and Brass Foundries.—These are numerous, scattered over Bombay, Sind, Madras, Bengal, the Panjab, and Burma.

Jute Presses.—All these are in Bengal. One is reported to have been started in Jubbulpore and two in Benares for the pressing of hemp.

Lac Factories.—There are forty-one of these in the North-Western Provinces, all at Mirzapur. The number in Bengal is not fully stated; they are numerous, and, excepting the factory at Cossipore, near Calcutta, mostly small.

Mineral and Aërated Water Manufactories.—These are numerous, and scattered over every province; so far as information has been received, there are seventy-three in Bengal, thirty-seven in Madras, seventy-six in Bombay, twenty-three in Sind, seventy-three in Burma, sixty-four in the Panjab, seventy-seven in the North-West Provinces and Oudh, twenty-three in the Central Provinces, and three in Rajputana.

Mines (other than coal mines).—Incomplete. The mica mines in Hazaribagh (Bengal), the ruby and steatite mines of Upper Burma, the tin mines in Mergui, and the gold mines in Madras and Mysore are alone reported.

Oil Mills and Wells.—Incomplete. The expression of oil is largely carried on in various places, though the mills in most cases are small. The list includes the petroleum wells in Burma, which are the only wells as yet worked on a large scale, the wells in Assam, and the petroleum refineries at work at Rangoon and at Lakhimpur in Assam.

Potteries.—Under this heading are included the extensive potteries of Raniganj and Jubbulpore, belonging to Messrs. Burn and Co., of Calcutta, where piping, tiles, and other large articles are made in considerable quantity; also seventy-seven small concerns in the North-West Provinces and Oudh, six in the Panjab, and two in Bombay. The industry is widespread over India, and is increasing. Art pottery is produced in Bombay and other places, and native works turn out characteristic ware at Delhi, Multan, Aligarh, and elsewhere, though it cannot be said that the work is done on a large scale.

Quarries.—Two quarries are entered, that of the Rajmahal Stone Company with a capital of Rx. 25,000, and the Kangra Valley Slate Quarry Company with a capital of Rx. 12,000. There are eight lime quarries in Assam, of which three were not worked during the year.

Rice Mills.—Of these there are seventy in Lower Burma, one in Upper Burma, one in Bengal, three in Godaveri, one in Tanjore, sixteen in Kistna, eight in Coimbatore, one in Madras, and eight in the Bombay Presidency.

Rope Works.—Eighteen are entered, of which five are in the Madras Presidency, twelve in Bengal, all near Calcutta, and one in Bombay. The works near Calcutta are owned and managed by Europeans and produce rope and cordage fit for all marine and other uses. Native rope works are very common, but they are small and the rope inferior.

Saltpetre Refineries.—There are a great number of these, worked by natives on a small scale, in Madras, in Bihar, the North-Western Provinces, and about a dozen in and around Calcutta; one of the latter owned and worked by a European firm.

Silk Filatures.—With the exception of one in the Dehra Dun, these are all in Bengal.

Silk Mills.—Two silk mills at Bombay, and another in Calcutta, and various silk-weaving factories in Bengal. These latter, to a large extent, weave tasar silk, are owned and managed by natives, and do not employ European machinery and apparatus. The fabrics woven in the three mills are mainly intended for Burmese consumption.

Soap Factories.—Three at Meerut. One of these (the North-West Soap Company, with a branch at Calcutta) makes very good toilet soaps. There are many small native soap works in Bengal and other provinces, but the soap manufactured is crude and inferior.

Sugar Factories.—Six in Madras. In Bengal the large Cossipore factory, with a capital of Rx. 100,000, and numerous small factories, number not stated. In the North-Western Provinces two, the extensive Rosa factory at Shahjahanpur, with a capital of Rx. 160,000, and a smaller one at Cawnpore, and one in the Panjab.

Tanneries.—One hundred and fifty-one of these are returned, of which one hundred and thirty-eight are in Madras, six in Sind, one in Bombay, one near Calcutta, two at Cawnpore, one at Agra, one in Rangoon, and one in Ajmere. The leather works at Cawnpore are important and of large dimensions.

Tile Manufactories.—Thirty-two, of which twenty-seven in the Madras Presidency, one in Coorg, three in the Panjab, and one in Assam.

Timber Mills.—Of these there are seventy-four altogether, the majority of them in Burma.

Tobacco Farms and Factories.—The only entry under this head is the plantation belonging to Messrs. Begg, Dunlop, and Co., at Poosa, where tobacco is grown, cured, and manufactured after the American methods. Twenty-four factories for the manufacture of cigars have been reported in Trichinopoly, one in Madras, seven in Madura, and eight in the Godavari district. The cigar-making industry in Southern India has assumed large proportions.

Woollen Weaving Establishments.—Five of these are reported from the Panjab, where carpets are manufactured, but there are others elsewhere not reported.

ELEMENTARY AND HIGHER EDUCATION IN FLORENCE.

Elementary education in Italy is compulsory for children between six and nine years of age. Institutes for public instruction are maintained by the State either entirely or in conjunction with the commune. Those not belonging to the State must follow the

same programme as Government schools. In the year 1895-96 the number of children bound by law to receive elementary education in the commune of Florence was as follows:—(Children between six and nine years of age inscribed in public schools, 8,389; children in private schools, 2,052; children educated at home, 104; and those dispensed with for justified motives, 997. Secondary instruction (classical) is provided in the Gymnasium and Lyceum, the latter leading to the university. According to Consul-General Chapman, there is a technical, commercial, and professional school, the object of which is to educate girls as commercial clerks, accountants, translators, &c., in a word, to import to them, besides the ordinary course, such supplementary instruction as may enable them to attend to all professions requiring a moderate degree of culture. Very few schools of this sort exist in Italy. The present school was founded in 1879, and at present it consists of three classes, in which the following education is imparted:—First-class.—Italian, so as to enable pupils to compose with facility and precision; arithmetic, as a preparation for book-keeping; geography, French and English languages. Second-class.—Commercial correspondence, theoretical and practical book-keeping, commercial geography, French and English languages, political economy, civil and commercial law, &c. Third-class.—Continuation of the study of the above subjects in conjunction with their practical application, especially with reference to trade and commerce. There is no limit of age, but an examination is prescribed for admission which, for the first-class, should correspond to that for obtaining an elementary certificate, and for the second-class, to that required for admission to normal and secondary schools. The admission fee, originally very small, has been gradually raised to £1 10s. In the year 1883, the new president commendatore, Edward Philipson, an active supporter of anything advantageous to Florentine interests, gave a fresh impetus to the school by proposing, in the first instance, the formation of a committee of lady patronesses chosen among the leading families of Florence, with the view that they should periodically visit the school, assist the lady director in her office, be present at the examinations, and also look after the employment of the girls leaving the school with certificates. In 1884, this institution was officially recognised by the Government as a girls' technical school, the programme being slightly modified in conformity with the Government regulations. Tuition in national and natural history, geometry, and drawing was also added. In 1892, it was further supplemented by a "professional" section formed, by the help of Princess Corsini, for the teaching of needlework, ironing, mending, &c., which is attended by about 40 pupils. The average annual number of girls attending the technical and commercial sections is about 100.

Besides 21 universities there are in Italy 13 superior institutes or smaller institutes having special faculties:

of these three are situated in Florence, and comprise (1) the institute of higher studies, (2) the high school for girls, and (3) the school of social sciences and jurisprudence. The institute of higher studies comprises the following faculties:—Philosophy and literature (four years' course), physical and natural sciences (four years' course), medicine and surgery (six years' course), chemistry and pharmacy (five years' course), and midwifery (two years' course). It was founded in 1859 and its present organisation dates from 1872, under an agreement between the Government, the province, and the commune of Florence. Its administration is entrusted to a board of directors consisting of six members, three of whom are appointed by the commune, two by the Government, and one by the province. Not being a body corporate this institute possesses no patrimony, and the buildings, collections, and equipment are State property. By Article 3 of the above-mentioned agreement the annual allowance for the maintenance of the institute was fixed at £21,600, the State contributing £1,300, the remainder being paid one-third by the province and two-thirds by the commune. In 1896 the total revenue amounted to £29,567 and the expenditure to £28,692. Professors receive between £200 and £320 per annum. On its staff of teachers are Senatore Pasquale Villari; Commendatore Severini, Professor of Asiatic languages; Commendatore Giglioli; Professor Lustig, the discoverer of the serum for curing the bubonic plague; Senatore Mantegazza, and many others. Annexed to this institute there is a national museum of anthropology and ethnology, an Indian and a psychological museum, a museum of ancient physical and astronomical instruments, a meteorological observatory and many cabinets and laboratories, the latter being partly on the premises and partly annexed to the museum of natural history in the via Romana, which also belongs to the institute. It is also furnished with an Oriental printing office, under the superintendence of the president of the faculty of philosophy and philology, possessing all the Oriental type which belonged to the once celebrated Medicean printing office, consisting of Arabic, Turkish, Persian, Syriac, and Armenian, to which other types of all sorts of Asiatic languages have been added.

VITICULTURE IN RUSSIA.

Although the results of last year's grape harvest, especially in the Crimea, were disappointing—a fact due to unfavourable weather, and to the ravages of the phylloxera—viticulture in Russia has within the last fifteen years made enormous strides. At one time confined to the south-east of the Crimea, it now extends in a northerly and north-easterly direction into the provinces of Kherson, Podolia, and Bessarabia, some of the plantations, notably that of Prince Troubetzkoï, covering an area of 500 acres. In the Government of Bessarabia in particular, the progress made, according to the Acting British

Consul-General at Odessa, has been very marked, both in the extent of land under cultivation, and in the quality of wines produced. The former fact is brought out by a comparison of the area under cultivation in 1893, which amounted to 108,000 acres, and that in 1897, which was 175,000 acres. The latter fact is evident when we consider that a province, which at one time produced only wine rated as very inferior, has now gained a reputation for the quality of its superior wines, which are quite equal to good quality French wines, over which they have a considerable advantage in point of price. The causes militating against the wine harvest in the Crimea have also been present in Bessarabia, so that the finer quality wines are this year more limited in quantity and higher in price than in a good season. The quality of the Bessarabian wines, both red and white—the red bearing a close resemblance to Burgundy, the white partaking of the nature of hock—should render them acceptable in England and other countries, and it is confidently believed that in course of time Russian wine will compete, with effect, on the markets of Europe; in fact, it may be worthy of note that it figured in 1897 among the exports from South Russia, when the first shipment of the kind was made to the British Isles. The development of viticulture has led to the establishment, in Odessa, of two champagne factories. One of these has not yet commenced operations, but the other has been working under most favourable circumstances for some time, competing most successfully with French champagne.

EMPLOYMENT OF WOMEN IN GERMANY.

The German Government appears to be following the example of England and America in employing women in the Post-office Department. The experiment of using them as clerks and directors of smaller post-offices has been satisfactory. The department is now, according to the United States Consul at Freiburg, going a step further, and is appointing women assistants in the telegraph and telephone offices. A great many women have also been appointed to take full charge of smaller post-offices, preference being given to the widows of deceased postmasters. Those who have been in the employ of the Government a long time, are to receive a salary of 1,200 marks (£60) per annum, with an extra allowance of 500 marks (£25) for house rent. In Norway, women have for some time been employed in the railway and post-office services, and are now receiving appointments as supervisors of railway stations. They receive the reports from the guards, answer the questions of travellers, call out the trains in the waiting-rooms, ring the station bell at the departing of the train, and telegraph its departure to the next station. They perform the duties of Government telegraph operators, and often those of postmasters.

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*All communications for the Society should be addressed to
the Secretary, John-street, Adelphi, London, W.C.*

Notices.**EXAMINATIONS, 1899.**

The dates fixed for the Society's Examinations in 1899 are Monday, March 13th, Tuesday, 14th, Wednesday, 15th, and Thursday, 16th.

The Programme of Examinations is now ready. Copies of the Programme, with full details, and an Appendix containing last year's questions and reports by the Examiners, can be had, price 3d., post free, on application to the Secretary, Sir Henry Trueman Wood, Society of Arts, Adelphi, W.C.

Proceedings of the Society.**CANTOR LECTURES.****ELECTRIC TRACTION.**

BY PROF. CHARLES A. CARUS-WILSON,
M.A., M.Inst.C.E.

Lecture I.—Delivered May 2, 1898.

The subject about which I have been announced to speak to you to-night is a very wide one, and you will understand that it is impossible in the short time allotted to cover anything but a very small area of the field of electric traction, and that it will be necessary to confine ourselves to some special branch of it. I propose, then, to direct your attention to some principles connected with the subject of the direct current motor in its application to electric traction.

The old ideas that we used to have of the treatment of this subject are proving to be inapplicable to the solution of many problems that are now pressing upon the electrical engineer. If, for instance, you were to ask those who are designing the electrical equipment of the Central London Railway which is now being made from the west to the east of

London, they would tell you that there were problems in connection with that enterprise which had not hitherto presented themselves for solution to electrical engineers. These problems are almost entirely connected with the motor element of the electrical equipment, and it is to them that I propose more particularly to direct your attention in the following lectures.

Although I have been announced to speak on the subject of electric traction, the first thing I am going to do is to ask you to consider the electric motor in a state of rest. This may appear to be unreasonable, but we are too much accustomed to consider the motor as being always in a state of motion, and the reason why I am going to confine my remarks to-night entirely to the motor in a state of rest is because the solution of the problems to which I have referred can be arrived at only by a thorough knowledge of what is going on in an electric motor when it is at rest. If we can understand what is taking place in an electric motor when it is at rest, it will be easy to understand its action when it is in motion.

At the risk of going over ground that must be familiar to many present, I propose to describe briefly the relation between the armature and the magnets of a motor. Here I have a direct current motor, made by the Crocker Wheeler Company, of Ampere, in New Jersey, and kindly lent me by the General Electric Company. This particular motor is not designed for electric traction, but I need not say that the principles on which it acts are identical with those that are so designed. Now in the electric motor we have the two parts, the armature, and the magnets. Let us briefly notice what takes place. Suppose that Fig. 1 represents a section of an armature and pole pieces, taken at right angles to the shaft. All round the armature there lie a number of wires parallel to the shaft, which are called surface conductors, because they lie on the surface, being thus distinguished from those that lie inside the armature, and are of no use for producing force. Suppose that A and B represent two of these conductors lying on each side of the armature. When a current passes through the motor we have current passing in one direction on one side of the armature, and on the other side in the opposite direction, as shown by the cross at A and the dot at B. When we send a current through the magnets, we get lines of force through the magnetic circuit of the motor, the direction of which is

indicated by arrows in the figure. The result is that we have a force on the wires, the direction of which is shown in the figure. Now on the other side of the armature the current is in the opposite direction, so that the mechanical force on the wire is reversed. We have thus a twist or torque tending to turn the armature to which the conductors are fixed.

To illustrate what I have been saying I am going, firstly, to magnetise the magnets by passing a current through the shunt-winding. These magnets are now strongly excited, and the lines of force are passing through the magnetic circuit. Now I am going to pass a current through the armature, and the current will be indicated on this ammeter. This is a Weston ammeter with an illuminated dial, kindly lent by Messrs. Elliott Brothers, it is

ture; that is to say, supposing we have a magnetic field of constant strength, and pass a current through the armature of gradually increasing amount, we should see this scale gradually pulled further down, indicating a gradually increasing pull.

On the other hand, we see also that if we keep the current in the armature constant, and vary the strength of the magnetic field, we find exactly the same effect as before; that is to say, the balance would be pulled down exactly in proportion as we increased the strength of the field. Now, for the present, I am going to express the strength of the field by the letter *M*, so that we may say that *T* varies as the product of *C M*, where *C* represents what is varying in the armature, and *M* represents what is varying in the magnets.

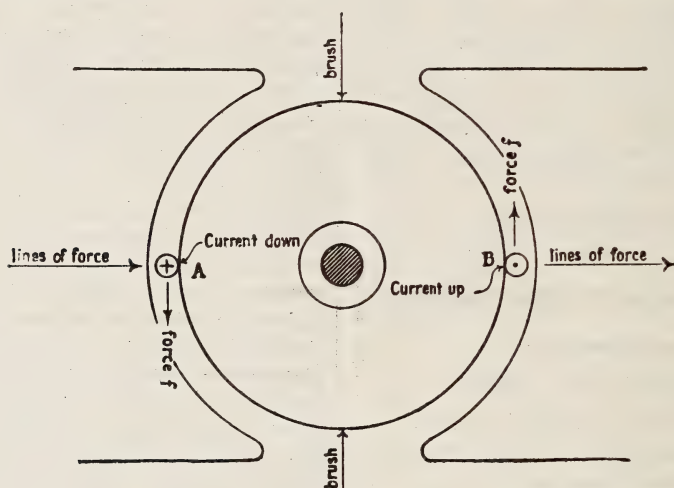


FIG 1.

calibrated up to 15 amperes, and measures the current passing in the armature of the motor.

This spring balance is attached to a cord passing round this wooden pulley, which is keyed on to the shaft, so that we can measure the force. We have now got a current of 5 amperes passing in the armature, and we have a pull on the balance of 16 lbs. Here, then, we have the very simplest illustration of the twisting force produced by a current when it passes through the conductors of an armature in the presence of a magnetic field.

Now there are two elements which go to make up the force which we have here measured; the one is the current in the armature, and the other is the magnetic field. Suppose that we write *T* for the pull on the spring balance, then we see that *T* varies in the first place as *C*, the current in the arma-

I want to say a few words about this quantity *M*. I have spoken of it briefly as representing the strength of the magnets, but we have to be very much more precise of course than that, and we must inquire more exactly what this quantity *M* represents.

It is always a help to give a thing a name, and we will call *M* the induction-factor of the motor. Now the induction-factor can be expressed by a very simple formula, namely—

$$M = \phi A N 10^{-8}$$

This is a very easy formula to remember, and we shall find it very useful.

In the first place, *A* represents the number of conductors on the surface of the armature; that is to say, if we take this armature out of its place, and take of all the wrapping surrounding it, and find how many conductors

there are lying on the outside surface of the armature, this would give us what we call A , the number of surface conductors. In this machine the number of surface conductors is very easily found, because there are 32 slots cut in this armature, and in each one of those slots there are 32 conductors, making in all 1,024 surface conductors, so that for this particular dynamo A is 1,024. We are sometimes liable to be misled in counting the number of conductors, because the conductors are sometimes arranged in parallel with one another, and two may only serve actually as one conductor, so that we have to be careful in counting the number of conductors round the surface of the armature not to count as two conductors two wires which are really simply acting as one. In this case each one of these 32 conductors in each of these 32 slots is carrying half of the whole current that goes through the armature, so that we know we are not making a mistake.

The quantity, ϕ , that I have written down depends upon the way in which the armature is wound. In the case of a machine with two poles ϕ is unity, and in every bi-polar machine ϕ must be unity; but when you come to four poles, ϕ may be one or it may be two, according to the way the armature is wound, whether in series or in parallel. Generally we may define ϕ as being the ratio of the number of surface conductors in series between the main terminals of the machine to the number of surface conductors lying between two adjacent neutral points. It is obvious that in a two-pole machine this ratio must be unity, but in a four-pole machine it may be two or may be one, according to the way the armature is connected.

The quantity N is of an essentially different nature to either of the two quantities A or ϕ , since these are fixed for any given machine, and cannot be altered; that is to say, you cannot alter the number of surface conductors on a machine, and you cannot alter the way the armature is connected up. But N is not a fixed quantity, since it is the number of useful lines of force which enter the armature from any one pole, and consequently, we are able to make N vary as we please by varying the current passing round the magnets.

Let us take this motor, and see if we can calculate M roughly from the equation I have given you. Here we have $\phi = 1$, and $A = 1,024$. What is N for this machine? How many useful lines of force are there per pole? We know that the number of lines of force per

pole, passing across the air gap from the pole into an armature of a machine of this kind, must be somewhere about 4,000 or 5,000 lines per square centimetre; let us say 4,500. I have measured the area roughly, and find it to be about 8 centimetres this way, and 17 centimetres that way, giving us about 136 square centimetres; multiplying this by the 4,500 lines per square centimetre, we get 610,000 as a rough estimate of the number of lines per pole. Hence we find the value of M to be 6.2, that is to say, this quantity that I call the induction-factor has in this particular motor a value roughly of about 6. We shall find that the induction-factor will form the basis of all our calculations about the action of a motor in electric traction, and it is absolutely necessary to have some such factor as this in our minds when we are talking about a motor. When you tell me that a motor has an induction-factor of 6, I can tell you exactly what that motor will do under any conditions.

Hitherto I have attempted simply to calculate the value of M , assuming a certain value for the number of useful lines per pole. Let us see how we can measure this quantity M . One of the simplest ways of doing this is to measure mechanically the pull produced by a given current. We can then find M by a very simple formula which I will give you.

Suppose that t represents the twist or torque on the shaft in inch-pounds. Then if the motor has an induction-factor of M , and the armature is carrying a current of C amperes, the torque in inch-pounds on the shaft of the armature is given by—

$$t = 1.41 \text{ C M.}$$

We can use this formula in two ways, we can either take M as known and find the torque for a given current, or measure t and find M . We will suppose that we do not know what M is, and find M by measuring the torque for a given current. You will notice that the torque of which I am speaking is simply the pull indicated on the balance, multiplied by the radius of the pulley round which this cord is passing. In this case the diameter of the pulley is $5\frac{1}{2}$ inches, so that the radius is 2.75 inches, and we have simply to multiply the pull as indicated on the scale by 2.75 to give the torque. We must be careful to notice that we get a small indication on the scale without any current in the armature; this is due to the fact that it requires a certain amount of force to turn the armature against the friction of the bearings of the machines and the brushes. There is no current passing now, and in this

case it requires nearly 2 lbs. pull on the balance to turn the armature. So that you see when we want to find exactly how much torque is produced by the current we have to deduct this 2 lbs. from the pull as indicated on the scale.

I will first of all magnetise the magnets, and then I will send the current through the armature. There is now a current of 6 amperes passing, and the pull on the scale is 21 lbs. From this we have to deduct 2 lbs. for friction, giving us 19 lbs as the effort actually produced by the action of the current on the magnetic field. We have to multiply this by 2.75, giving

multiplying the current by 1.41 times M, thus obtaining the torque in inch-pounds for that current.

The quantity M varies with the number of useful lines of force passing from each pole into the armature. Suppose that we make an experiment, and vary the magnetising current in the magnets, and for each current that we have there passing, observe the pull on the balance, we could then, by the method I have just shown you, measure the value of M for each value of the current in the magnets. We could, in that way, get a curve, which I shall call the induction curve, such as we have here

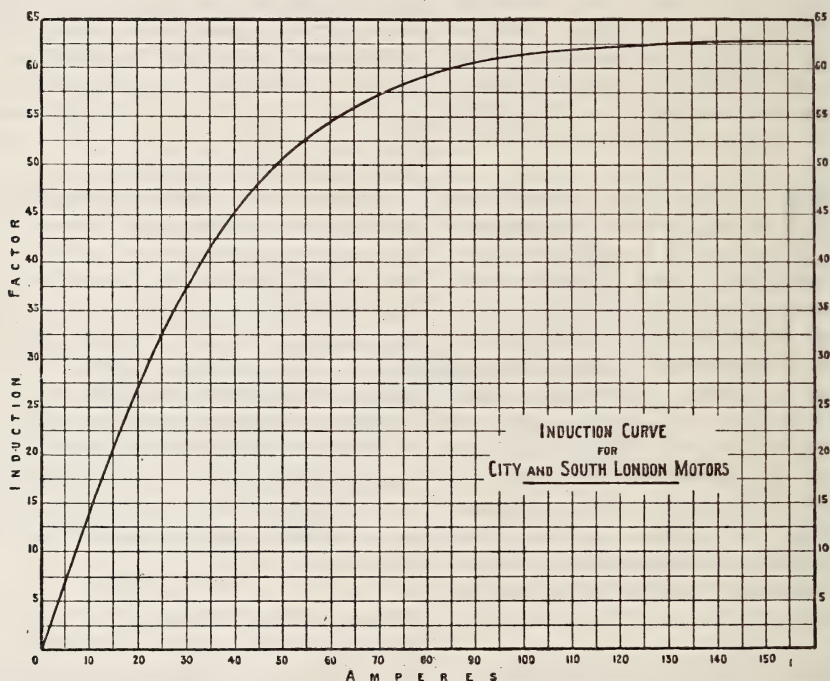


FIG. 2.

us 52.5 inch-pounds of torque. We have now simply to equate this to $1.41 CM$, where M is the unknown quantity and C is 6 amperes, and we get the value of M roughly about 6.

You see this is a very simple way of measuring the induction-factor of this machine. It has been done quite roughly, but it shows how it can be done in practice; that is to say, we have here a method of finding the value of M, the induction factor. When once we have determined the value of M for any machine, the number of useful lines of force passing through the armature being constant, we can tell exactly what mechanical effect we shall get from that machine for any given current by

in Fig. 2. If we set off the values of the magnet current in amperes horizontally, and the value of M vertically, we shall get a curve which you will all recognise as being very much like what is called the characteristic of the machine. Perhaps you say "Why do you not call it the characteristic of the machine instead of calling it the induction curve?" Well, in the first place, it is not the characteristic, and in the second place it has a great many advantages over what is called the characteristic, as I hope to show later on. You will have noticed that all this time I have assumed that the armature is at rest. Now when we speak of the characteristic of a

machine, we suppose that the machine is running at a certain speed. Hitherto I have said nothing at all about speed, I have considered simply the motor in a state of rest. I want you to understand that this induction curve represents the magnetic condition of the motor in a state of rest. I can obtain the characteristic from the induction curve by simply multiplying the value of M by the number of revolutions per second. The induction curve is the basis of all characteristics, and is entirely independent of speed.

The figure I am now showing you on the screen is the induction curve of the motors used on the City and South London Railway. Amperes in the magnets are measured horizontally, and corresponding values of the induction factor vertically. You see that the current in the magnets goes up to 150 amperes, and the value of M increases from nothing to a little over 62. In the motor we have here on the table, the magnetisation is produced by what is called a shunt winding, that is to say, that the current through the magnets is entirely independent of that through the armature. In the machine, whose induction curve is given in Fig. 2, the current through the magnets is the same as that which goes through the armature, and this has a very important influence on the mechanical effect produced.

Let us consider what result we should get if we increased the current in the magnets, and observed the value of the torque in a machine of this kind. If we could neglect the reluctance of the iron in the magnetic circuit, the induction curve would be a straight line passing through the origin, *i.e.*, M would be directly proportional to the current. Now, the torque is proportional to the product of M and C , hence the torque would vary as the square of the current. In practice we cannot neglect the reluctance of the iron, and the induction curve therefore bends over as in Fig. 2, with the result that the torque increases as the square of the current only near the origin. If however we could make the iron portion of the magnetic circuit so massive that we could neglect the magnetic reluctance of the iron, the torque would increase as the square of that current. Herein lies the great advantage of using what is called series winding. We shall find that in the design of railway motors, this increase in the torque, due to series winding, is of the greatest value.

It is clearly of the utmost importance to reduce as much as possible the saturation of the iron, because if the value of M does not increase

directly with the current, the curve bends over, and the torque does not then increase as the square of the current, but at a very much lower rate. I may illustrate this by the curve in Fig. 2. You see that instead of the induction factor increasing with the current in the magnets, it bends over rapidly. This is entirely due to the saturation of the iron. If this motor was going to be used with currents not exceeding 40 amperes, we should find the torque increasing as the square of the current, since up to that point M increases nearly directly as the current. As a matter of fact, this machine is used for currents ranging from about 75 amperes up to about 150 amperes, where you see the induction-curve is very nearly horizontal, so that although this motor is series wound, it has none of the advantages of a series wound motor. That is to say, instead of the torque increasing with the square of the current, it increases only very little more than the first power of the current.

In Fig. 3 we have the induction curve of a well-known series wound motor made by the General Electric Company, and called by them the G.E. 800 Railway Motor. The induction curve is obtained by a method that I shall describe later, not by the torque method. For a current of 20 amperes in the machine the induction factor is 40, while for a current of 40 amperes the induction factor is nearly 60. The maximum current in this machine is generally about 40 amperes, and the minimum is about 15 amperes. Between those limits the induction curve is fairly straight, though it is beginning to bend over owing to the saturation of the iron. You see that the induction curve is very much more straight between the limits of current through which this machine is being used than the curve in Fig. 2.

From the induction curve I have constructed a torque curve, by using the formula giving the torque in terms of C and M ; that is to say, I have taken different values of the current and multiplied by 1.41 times M , the corresponding value of the induction factor, and set up vertically a distance representing the number of inch-pounds of torque.

You see that I have here drawn two torque curves, one is the curve of total torque obtained from the induction curve, and the other is a curve which lies a little below it. This second curve is obtained from an actual test of the motor, and represents the number of inch-pounds of torque actually observed on a brake, while the motor was running. The small circles in

the figure are points of actual observation. You notice that this curve lies below the other curve. What is the meaning of that? It means simply that of the total torque produced by the action of the current on the magnets, and obtained by the equation 1.41 C M , a certain amount is lost in overcoming internal friction, hysteresis, gear loss, &c., so that the ratio of one ordinate to the other, for any given current, represents the mechanical efficiency of the motor for that current.

hysteresis, &c., leaving only 2,780 inch-pounds of torque available for useful effort. This gives us the mechanical efficiency, which is equal to 84 per cent. This is a small per-centage, but it must be borne in mind that the loss of 540 inch-pounds includes the loss of the gearing which is considerable, and that in a gearless equipment the per-centage loss would be very much less, and the mechanical efficiency might be as high as 94 or 95 per cent. We have thus arrived at the stage at which we

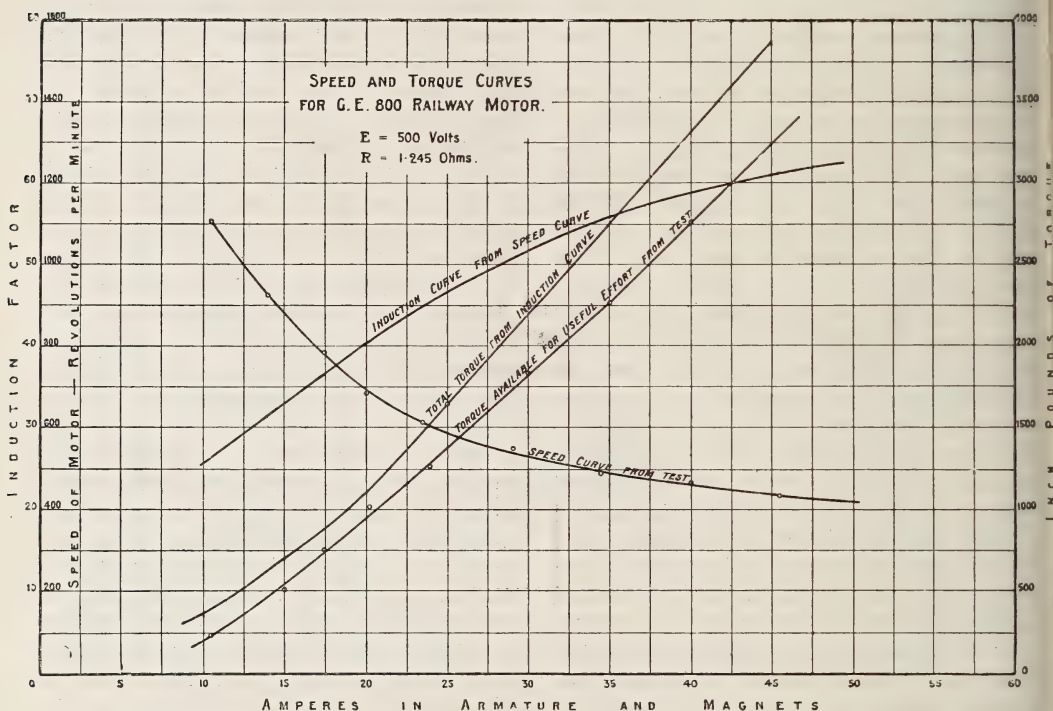


FIG. 3.

In Fig. 4 we have the efficiency curves for this motor for any given current, the loss due to the friction of the gears, &c., is set off vertically as a certain per-centage of the whole amount of energy supplied to the motor, and you see that each vertical ordinate represents the per-centage available for useful effort, after deducting that lost in heating and overcoming frictional and other resistance to motion.

Let us now make a short calculation about this motor; suppose that we take a current of 40 amperes. You see that the value of the induction factor for this current is about 59. If we multiply that by 1.41 times 40 we get a total torque of 3,320 inch-pounds available for all purposes. Now of this amount of torque a certain proportion, 540 inch-pounds, is lost in overcoming friction of gear and bearings,

can calculate the precise amount of torque produced by a given current in a motor, when we know the number of surface conductors, and the number of useful lines of force passing through the armature. We must now proceed to consider how the torque on the shaft of the motor is communicated to the draw-bar of the railway-car in actual practice. Referring once more to the action of this motor on the table, it is obvious that it makes no difference whether this cord pulls a weight up vertically, or acts against an equal force horizontally. Let us suppose that it acts horizontally, that is to say, that a cord runs off this pulley in a horizontal direction. It is clear that we should have exactly the same dynamical conditions if the end of the cord were fixed and the pulley free to roll along a horizontal rail. The func-

tion of the cord is now to ensure that the pulley rolls without slipping. We can effect this

The force which we have hitherto considered as acting at the rim of the wheel now appears

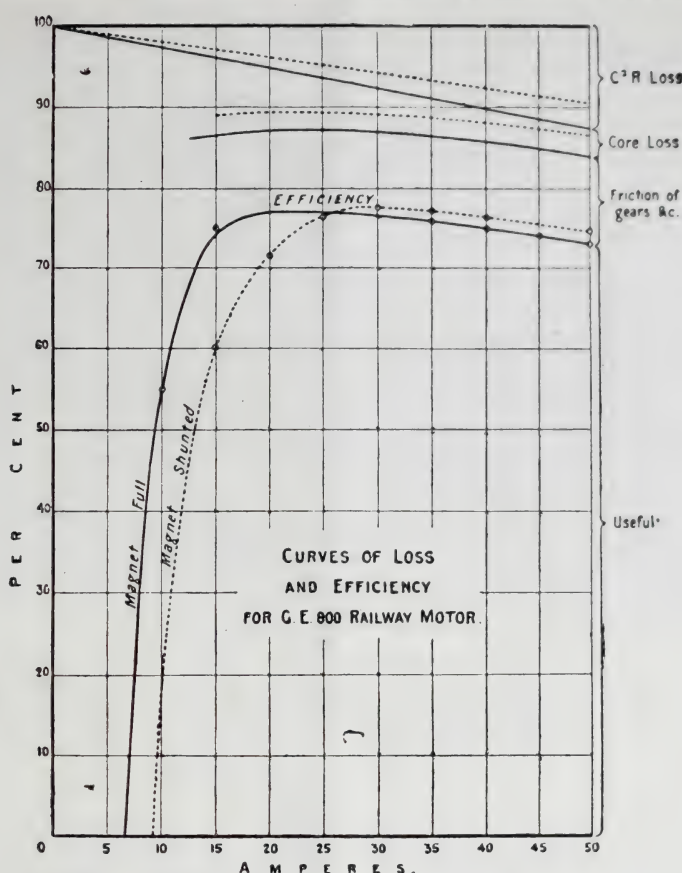


FIG. 4.

equally well by pressing the pulley on the rail. If the resistance to slipping caused by the pressure exceeds the original pull, the cord

as a force acting at the centre of the wheel parallel to the rail, tending to push the whole motor along the rail.

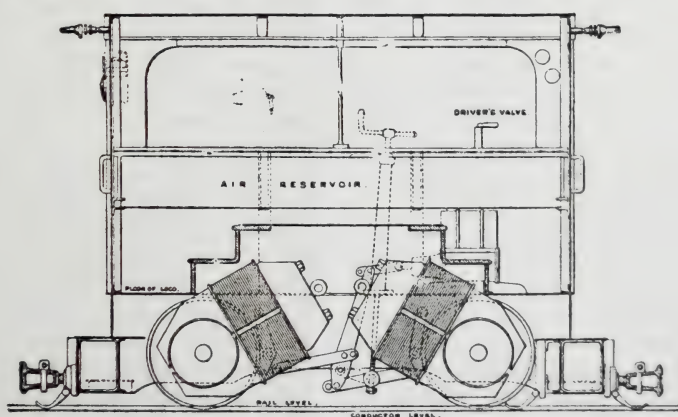


Fig. 5.

may be dispensed with, and we then have the conditions of an ordinary railway motor.

Fig. 5 is a view of one of the locomotives used on the City and South London Railway.

The armature of the motor is concentric with the axles of the driving wheels; these correspond to our wooden pulley, and roll on the rail. The torque produced by the action of the magnets on the current in the armature tends to make this wheel roll along the rail.

Let us see how we can apply our equations to find out the amount of the pull obtained by using two such motors in a locomotive of this kind. First of all we must observe that the torque produced is equal to the product of the horizontal force, T , acting at the centre of the wheel, called the draw-bar pull, multiplied by the radius of the wheel; that is to say, T multiplied by half the diameter of the driving wheel is the t that we have used in our equations. In this case the wheels are 27 inches in diameter, so that all that we have to do is to know what is the value of the induction factor of these motors for any given current and the mechanical efficiency, and we can at once tell what amount of draw-bar pull or horizontal effort available for hauling purposes we can get with two of those motors. If we refer to the induction curve of these motors, which I have shown you in Fig. 2, we shall see that for 150 amperes in the motor the value of the induction factor is 63. If we put these values in the equation $t = 1.41 C M$, remembering that $t = T \frac{d}{2}$, where d is 27 inches, we shall find that T is 980 lbs. Now this is the total pull produced by each of these motors with 150 amperes, so that we have to deduct what is lost in overcoming friction. We put that in the way of a certain per-centage of mechanical efficiency. Let us suppose the mechanical efficiency is 95 per cent., we should have then 936 lbs. per motor of horizontal effort available for useful purposes, or a total of 1,872 lbs. for the whole locomotive. You see then that when we have the induction curve of the motor, and the diameter of the driving wheel, we can tell exactly how much horizontal pull we can get from the locomotive for any given current.

The case that we have just considered is the simplest of all, since no gearing is used, but in the majority of cases the armature of the motor is not mounted directly upon the main driving axle of the locomotive, but is connected to it by means of gearing, that is to say, a spur wheel is placed on the main driving axle, and on the shaft of the motor is keyed a small wheel, the pinion meshing into the spur wheel. We then have three wheels, the spur wheel, the pinion, and the driving wheel. The only alteration that

has to be made in our equations is that the amount of torque that we get with a given current in the motor is greater than what we should get if that motor was put directly on the main driving axle, in the proportion of the number of teeth in the spur wheel, to the number of teeth in the pinion. If we call v the velocity ratio of the gearing, that is the ratio of the speed of the motor to that of the driving axle, which, of course, is the same thing as the ratio of the number of teeth in the two wheels, then we have simply to multiply by v to get the draw-bar pull obtained by a given current, with a given induction factor. Of course, the introduction of gearing would reduce the speed of the locomotive in the proportion of v to 1, so that the rate of working would be unaltered.

The only further change is that when we come to deal with gearing we cannot get such a high per-centage of mechanical efficiency, and instead of taking, as we have, 95 per cent. of mechanical efficiency, we shall have to be content with something like 85 per cent. Almost all the street railway equipments that are now being used are geared equipments, but some of the largest railway locomotives are made without gearing. The locomotives now being built for the Central London Railway are to be provided with a gearless equipment. I am sorry to find that they are being made in the United States by an American firm. There is not the least reason why they should not be made in Great Britain, and I hope that the next large electric railway will be engineered by a British firm.

I propose now to show you some views of standard geared equipments. Here is a standard geared equipment made by the Westinghouse Company, who have kindly furnished me with these photographs of their latest types of geared motors. Fig. 6 is a view of a 150 horse-power railway motor. It shows the complete motor as it is turned out from the works ready to be put on to the car. I shall not describe at any length how it is put on to the car. There are plenty of sources from which anyone interested in that subject can find out how this is done. I propose to take this motor into two pieces in order that you may clearly understand what there is inside, and how the force produced by the torque on the armature is converted into draw-bar pull.

Before we open up this motor I want to give you a typical diagram of the magnetic circuit of one of these railway motors. In Fig. 7 you have a section taken at right angles to the shaft of the armature. This is a four-pole

are four magnets in this case. Of course there are two distinct magnetic circuits. All the equations that we have hitherto discussed are applicable to such a machine as this. We have simply to know the number of conductors

on the surface of the armature, and the value of M , and we can find the torque produced by any current in that machine. I propose to divide the machine in two; that is to say,

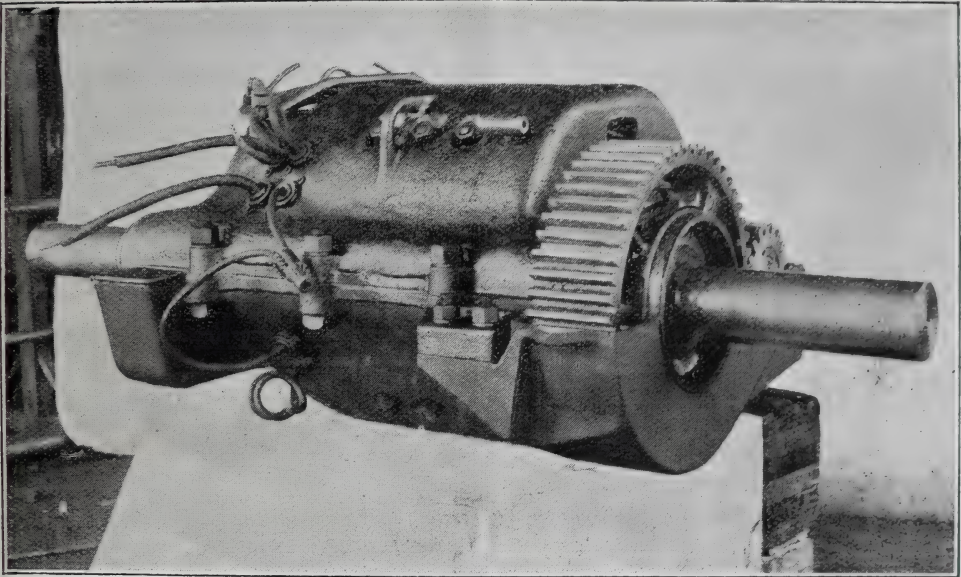


FIG. 6.

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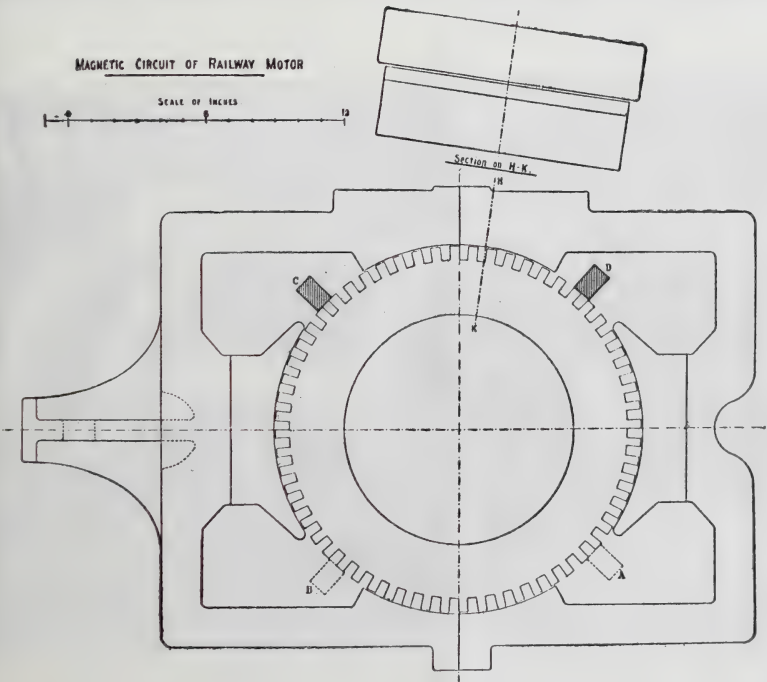


FIG. 7.

applicable to such a machine as this. We have simply to know the number of conductors

to remove the whole of the top and disclose the armature lying inside.

In Fig. 8 the top magnets have been removed, showing the inside with the bearings ready for the main shaft.

wheels are each actuated by one motor. This truck is used with a second truck, either with or without motors, so that the locomotive

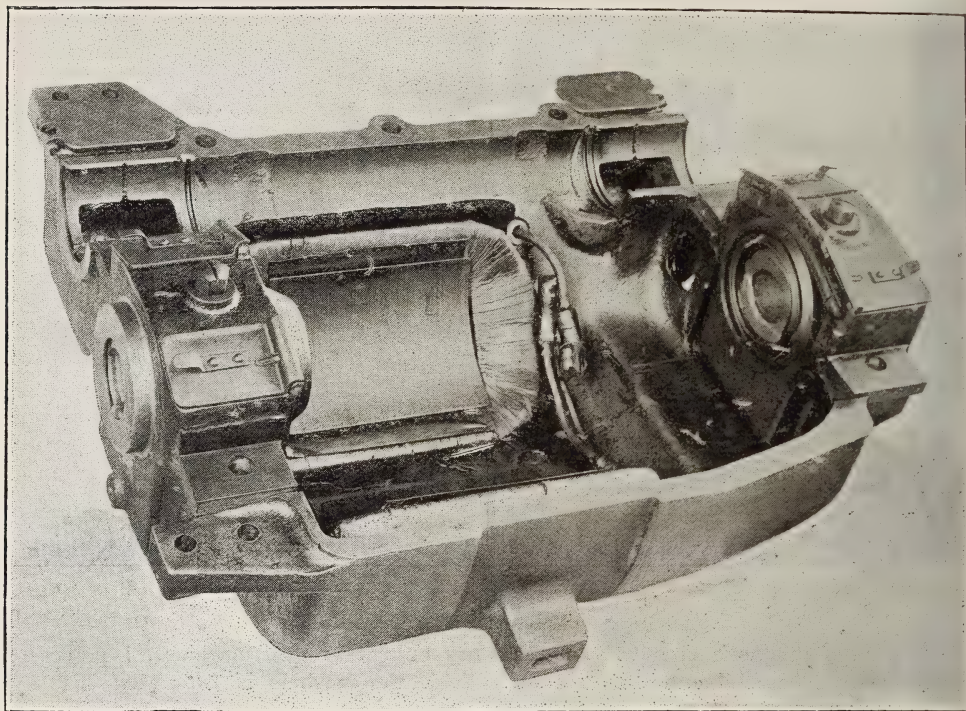


FIG. 8.

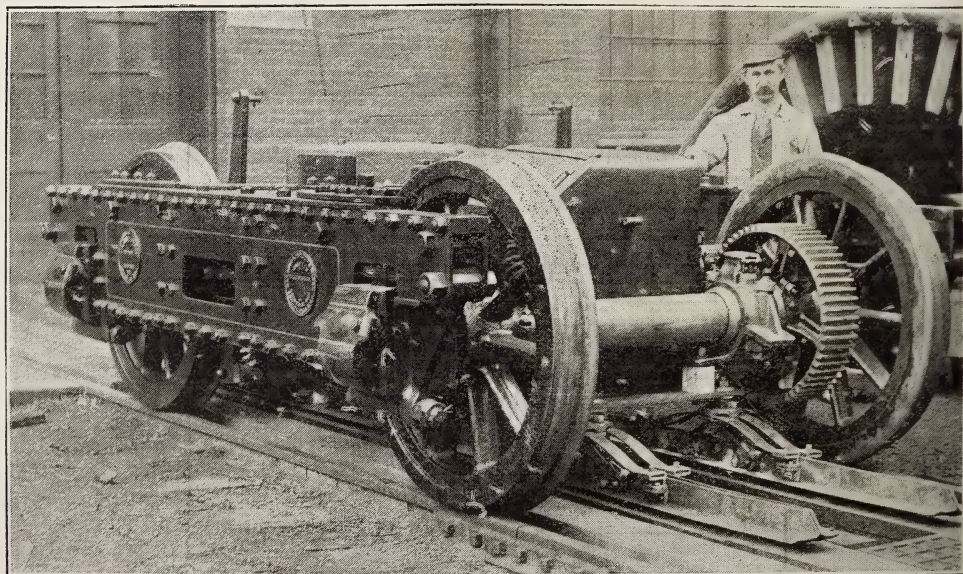


FIG. 9.

In Fig. 9 we see two motors mounted on what is called a truck. The main driving

may have two or four motors. Each truck is provided with a pivoted bearing, so that

a long car can be used with one of these trucks at each end.

In conclusion, I will calculate what effect we could get, supposing that this truck is equipped with two motors like the G.E. 800 motor, the induction curves of which you have already seen. In those motors, when the current was 40 amperes, the value of M was 59, and allowing 84 per cent. of mechanical efficiency, we get a torque of 2,780 inch-pounds. We have now to consider what is the value of the velocity ratio. A common ratio used in street railway practice is to have 67 teeth in the spur wheel and 14 in the pinion. That would give us a velocity ratio of 4.78.

Having settled the velocity ratio, all that we want to know is the diameter of the driving wheel. For street railway practice, 33 inch is very commonly used. If then we take a driving wheel of 33 inches in diameter, we get a horizontal pull of 800 lbs. available for useful purposes; that is to say, after deducting friction and all internal losses, a current of 40 amperes in one of these motors would give us a horizontal pull of 800 lbs. This is the origin of the name "G.E. 800." Two of such motors would give us a pull of 1,600 lbs., and if the complete locomotive contained four of these motors, we should get a total effective pull of 3,200 lbs.

Miscellaneous.

BOOKWORMS.

The following notice of certain species of bookworms is taken from a review in *Nature* of Father O'Connor's recently published "Facts about Bookworms."

The expression "*the* bookworm" is often used; but it is inaccurate, for some seven or eight species, perhaps more, actually do commit depredations in books. Besides, these creatures are not restricted in their diet to books. Dry food of no kind comes amiss, and one of the species which the author refers to, *Dermestes lardarius*, has received its specific name on account of the fact that it delights chiefly in bacon. *Anobium paniceum*, another beetle, is fond of books; but it feeds upon almost anything that comes in its way; the most singular food recorded as having been sought out by this exceedingly omnivorous insect is cayenne pepper.

Several other beetles and their larvæ fairly come under the designation of bookworms; and, indeed, it is only in this class of insects that we meet with species capable of producing those elaborately curved tunnels which often disfigure old books, and of which one or two samples are figured by Mr. O'Connor.

When uninterrupted in their ravages, some of these beetles are able to progress through the interior of books for quite a long distance, eating their way before them like an earthworm boring through the soil. Messrs. Kirby and Spence, and also Mr. O'Connor quote an instance of a bookworm which travelled through no less than twenty-seven folio volumes in so straight a tunnel that, by passing a string through the perfectly round hole that it had made, the entire set of volumes could be lifted at once.

To the popular mind the term "worm" implies anything of a smallish kind that scuttles, wriggles, or crawls; and with this notion is blended an idea of voracity and omnivorousness. We may fairly, therefore, put down, as does Mr. O'Connor, the "silver-fish" among the category of bookworms. This creature, *Lepisma saccharina*, is of course not a beetle, but a representative of that archaic group of insects the Thysanura; it is quaintly described by Hooke in his "Micrographia" as "a small white Silver-shining Worm or Moth which I found much conversant among Books and Papers, and is supposed to be that which corrodes and eats holes through the leaves and covers. It appears to the naked eye a small glittering Pearl-coloured Moth, which upon the removing of Books and Papers in the Summer, is often observed very nimbly to scud, and pack away to some lurking cranny, where it may the better protect itself from any appearing dangers." Unlike the black-headed bookworm, *Plinus fur* (which it has been suggested acquires its black head from its partiality to black letter books), the *Lepisma* lets printed matter severely alone, and carefully eats round it. The object of the *Lepisma* seems to be rather the paste than the paper or the binding. But it is not select in the matter of diet; and, among other foods, shares with the clothes moth a taste for garments and carpets. It has furnished Hooke with some physiological reflections which we quote from Mr. Butler's "Our Household Insects." "When I consider," observes the author of the "Micrographia," "what a heap of Sawdust or chips this little creature (which is one of the teeth of Time) conveys into its intrals, I cannot chuse but remember and admire the excellent contrivance of Nature in placing in animals such a Fire as is continually nourished and supply'd by the materials convey'd into the stomach, and fomented by the bellows of the lungs; and in so contriving the most admirable fabrick of Animals as to make the very spending and wasting of that fire to be instrumental to the procuring and collecting more materials to augment and cherish itself, which indeed seems to be the principal end of all the contrivances observable in bruit Animals."

A less obtrusive, though hardly less tiresome foe to the book-lover is an insect which has been called the "book-louse" (*Atropos divinatoria*). The term "louse," however, is unnecessarily offensive to the insect, for it is not parasitic and does not belong to the same group as that which contains the obscene *Pediculus*. It is a Neuropteran, allied therefore to

the dragonflies. It may be reasonably placed under the heading of bookworms—although Mr. O'Connor has not placed it there—owing to its partiality for paste. The specific name of the insect is connected with the fact that it shares with the Death Watch (a beetle) the habit of producing an ominous ticking sound, carrying terror to the heart of the superstitious. It appears, however, that this is merely an amorous conversation with, or an act of adoration directed towards the female insect, who is fascinated and overcome by this continued expression of feeling. This sound is caused by the insect knocking its head upon the ground, and it has been wondered, by those who under-estimate the power of love, how so small and tender an insect can create so loud a sound. Nevertheless it seems to be the fact that it does. The author, after dealing shortly with various kinds of bookworms, proceeds to the practical consideration of how to get rid of them. Paste containing such deadly elements as corrosive sublimate is recommended for binding purposes; elsewhere we have seen the suggestion that pepper is a useful article to mingle with the paste. But this would be obviously a substance of no use wherewith to confront that particular kind of bookworm which relishes a diet of cayenne. The general panacea for insects of all kinds is camphor. But here, again, the bookworm is not to be so easily combated. Specimens of one kind have been found comfortably and confidently nestling beneath pieces of camphor which it was hoped would put a speedy end to them. Possibly the best cure would be to put the books themselves to their legitimate uses, *i.e.*, to read them; this would necessitate a constant shaking which would prevent the pest from obtaining a secure lodgment. But considering that the Royal Society of Science of Göttingen in the year 1744, and the Society of Bibliophiles of Mons, in the year 1842, offered in vain a prize for the solution of these difficulties, it is not surprising to find that on the whole the bookworm has triumphed over the bibliophile and the naturalist.

BRIQUETTE MAKING IN GERMANY.

Consul Powell, of Stettin, in his last report, calls attention to a briquette factory at Langenburg, Pomerania, which is somewhat of a new venture, as it has only been in existence for two years, but has proved, so far, a complete success. It is the Consul's opinion that proprietors of turf moors in Scotland and Ireland might start factories of a similar nature with profit. The owner and manager of the factory has taken a patent in England for his machinery; it could therefore be employed either by purchase or by royalty. The turf at Langenburg is cut from the adjacent moor and is brought by water in an undried condition, and can be used immediately. The turf on coming from the moor is thrown into the first breaker-machine, somewhat in effect like a large turnip cutter, and in this it is broken into small lumps. From the first it passes to the second breaker, and is ground

into mull or a fine powder. From here it goes into the drier, a steam cylinder which is filled with the exhaust steam from the engine, and is perforated by tubes much in the manner of boiler tubes, but larger. This cylinder revolves, and being on a gentle slope, the mull passes slowly through the tubes and by this means becomes thoroughly dry. From the drier it passes to a hopper which feeds the plunger. This plunger receives the power of a 75 horse-power engine, and by pressing the mull in a form against the preceding briquette pushes them forward each stroke the width of a briquette. The factory turns out 80 briquettes a minute or 35 tons per day, with an average output of about 255,500 centners (12,775 tons) a year, and the demand is far greater than the supply, the reason for this being that the briquettes are so marvellously cheap, an average price being 6½d. per 130 briquettes, or at the rate of something like two briquettes for 1s. retail, that this is certainly the poor man's fuel, as they burn slowly and give a fairly good heat. In a closed oven one briquette will remain in a glowing state for 24 hours; in an open grate it burns more quickly, but remains for a longer time alight than any coal, giving a good red heat. The cost of working is comparatively light, as but few men are required to attend to the machinery. The cost at Langenburg of material and working one centner (112 lbs.) is 35 pf. (4¼d.), and per ton about 7s. With a more extended plant, the owner of this factory is of opinion that this could be reduced to 5s. per ton.

SANITARY INSTITUTE.

The twenty-sixth London course of lectures and demonstrations for sanitary officers will be given in the Parkes Museum, Margaret-street, W., on Mondays, Wednesdays, and Fridays, at 8 p.m., commencing October 17th. The lectures will be given by well-known authorities, and will comprise the following subjects:—Introductory Lecture. Sanitary Laws and Regulations governing the Metropolis. Sanitary Law—English, Scotch, and Irish; General Enactments; Public Health Act, 1875; Model By-laws, &c. The Law relating to the Supervision of Food Supply. Trade Nuisances. Objects and Methods of Inspection, Nuisances, &c. Water Supply, Drinking Water, Pollution of Water. Diseases of Animals in relation to Meat Supply; Characteristics of Vegetables, Fish, &c., unfit for Food. Infectious Diseases and Methods of Disinfection. Principles of calculating Areas, Cubic Space, &c.; Interpretation of Plans and Sections to Scale. Ventilation, Warming and Lighting. Sanitary Building Construction. Sanitary Appliances. Details of Plumbers' Work. House Drainage. Scavenging, Disposal of House Refuse. Sewerage and Sewage Disposal. In addition to the above lectures, the course will include a number of practical inspections and demonstrations illustrating the various matters with which a sanitary officer may have to deal in the course of his duties.

Journal of the Society of Arts.

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FRIDAY, SEPTEMBER 23, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.**EXHIBITION OF LITHOGRAPHY.**

The Lords of the Committee of Council on Education announce that they have decided, at the suggestion of the Council of the Society of Arts, to hold during the autumn an Exhibition of Lithography in the buildings of the South Kensington Museum, on the West side of Exhibition-road. As lithography was discovered by Senefelder in the year 1798, the present is the centenary year of the invention, and therefore offers a suitable occasion for such an exhibition as is proposed.

The Department will be assisted in the selection and arrangement of the exhibits by the influential Committee, with some additional members, which had been already organised by the Society of Arts. It is proposed that the Exhibition should be opened about 1st November, and remain open for four months. The lithographs will have to be sent in not later than 1st October.

Any further information will be furnished on application to the Secretary, Department of Science and Art, South Kensington, S.W., to whom all communications on the subject should be addressed.

PRACTICAL EXAMINATIONS IN MUSIC.

The practical examinations in Music were not concluded this year until the 13th July, too late for the results to be included in the Report of the Council. They lasted for 15 days.

The system of examination was the same as that for last year. Candidates are asked to select for themselves which of four standards they choose to be examined in. Standard I. is easy, Standard II. moderately difficult, Standard III. difficult, and Standard IV. very difficult. For each standard a list of music is

given, and a selection from this list is sent to the candidates six weeks previous to the examination. Candidates are expected to play or sing pieces from the selected list, as well as to play a piece, or a portion of a piece, at sight.

In all 539 candidates were examined, an increase of 147 over last year; 5 of these took up two subjects, so that there were 544 examinations. Of these there were 515 passes and 29 failures. The failures last year were considerably larger in proportion, being 44 in 405 examinations.

The following were the subjects taken up:—Piano, singing, violin, violoncello, mandolin, zither, and organ. 399 entered for the piano, of whom 376 passed and 12 obtained medals; 79 entered for the violin, of whom 75 passed and 15 obtained medals; 1 entered for the violoncello and passed; 1 passed for the mandolin; 4 entered and passed for the organ; 59 entered for singing, and 57 passed, 5 obtaining medals; 1 entered for the zither and passed.

Mr. John Farmer, of Balliol College, Oxford, and Director of the Harrow Music School, acted as Examiner, Mr. Ernest Walker, M.A., Mus. Bac. Oxon., and Mr. Burnham Horner, as Assistant-Examiners.

Proceedings of the Society.**CANTOR LECTURES.****ELECTRIC TRACTION.**

BY PROF. CHARLES A. CARUS-WILSON,
M.A., M.Inst.C.E.

Lecture II.—Delivered May 9, 1898.

In the last lecture we treated of the motor in a state of rest. To-night I propose to discuss the question of the motor in a state of motion. For this purpose I shall make use of the same motor as before to illustrate experimentally some of the points I want to bring to your attention. The first thing that I want to remind you of—I suppose there are few here who are not aware of the fact—is that a motor in action is at the same time, in one sense, a generator. In order to explain this more fully I will make an experiment. I have started this motor in the usual way, and these instruments are recording as before; the ammeter, *a*, giving the current in the armature, and the volt-meter, *v*, the tension at the brushes. The

connections are made as shown in Fig. 10. The magnet circuit is permanently connected to the line.

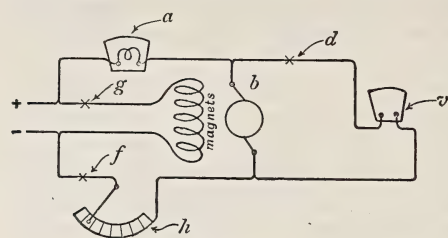


FIG. 10.

In the first place I want to show you that the tension at the brushes is the same as that of the line, both in sign and in amount. To do this I have simply to lift one of the brushes off the commutator, as at *b* in the figure, by doing which I virtually cut out the armature altogether, and you see that the volt-meter reading does not alter. Take no notice of what the ammeter is doing, observe only that when I raise the brush off the commutator, the volt-meter reading does not alter; that is to say, the volt-meter reading gives you the number of volts on the line to which the motor is connected.

I now have to show you that the motor itself is inducing a tension of the same sign, with respect to the volt-meter, as that of the line. To do this I shall, for an instant, break the circuit from the line at a point shown by *f* in the figure, and leave the volt-meter still connected to the brushes of the motor. You see that the deflection of the volt-meter is hardly altered at all. To show that this is not due to the inertia of the volt-meter needle, I will break the circuit as at *d*. You see how very quickly the volt-meter needle drops. This proves that the reading we observed when we broke the circuit at *f* was due to the tension induced by the motor itself acting as a generator. When I disconnect the motor from the line, there will be an indication on the volt-meter as long as the motor is moving. Of course, directly the circuit is broken at *f*, the motor begins to run slower, but there is still a reading on the volt-meter; and in order to prove to you that the reading you have there is being induced by the motor, I will lift the brush off the commutator, and you see the needle drops at once. As long as there is any motion, we get a tension induced, and an indication on the volt-meter. I would ask you then to remember, that as long as the motor is moving, it is inducing a tension of the same sign, with respect to the volt-meter, as that of

the line. This result is of great importance, because it follows that in the armature itself, the tension of the line, and the tension induced by the motion of the motor, are opposed to one another. I do not like the term counter-electro-motive force, but prefer to use the expression induced tension, and to say that the tension induced by the motion is opposed to that of the line in the motor armature.

Now this question arises. "If a motor is moving at a certain rate, how many volts will be induced by the motion at the terminals of the motor?" The answer is very simple. If you remember, last week I introduced you to what I called the induction factor. If *n* represents the number of revolutions per second of a motor, to get the induced tension at the terminals of the brushes you have simply to multiply *n* by *M* the induction factor, and you get the induced tension in volts at the terminals of the motor. Suppose this armature to be running at 1,200 revolutions a minute, that is at 20 revolutions a second. We found last week that the induction factor of this motor was about 6: hence the induced tension at the brushes would be 6 times 20, that is 120 volts. If then you know what the induction factor is, you know that when it is running at any given speed, you have simply to multiply the revolutions per second by the induction factor, and that at once gives you the induced tension in volts at the terminals of the motor. And generally, if you have a motor running under any conditions whatever at a known speed, the motor will be inducing a certain number of volts, which number is given by the product Mn .

Wherever we have a current passing, the strength of that current must always be determined by Ohm's law. This law holds equally well in the case of a motor when it is running as it does in the case of any other conducting circuit. The only difference in the case of the motor is that the tension which is sending the current through the armature is the difference between that of the line and the induced tension. This motor is now running at 1,040 per minute, and the induction factor is now 6.1. When the motor is running at that speed with that induction factor the tension induced is exactly 106 volts. The tension of the line you see to be 107 volts. Hence the effective volts which is causing the current to pass into the motor is 1 volt. You now only want to know the resistance of the motor; that is about 1 ohm, according to a rough measurement that

I made before the lecture, so that you get the current to be 1 ampere. The motor is now running at full speed, and you see that the ammeter reads almost exactly 1 ampere.

I may remark in passing that we have here a useful method of finding the induction factor of a motor. I gave you last week a method, by which we found the induction factor by determining the amount of torque for a given current. This is a much better way. You have simply to run the motor at a measured speed, n , observe E , the volts on the line, and C , the current in amperes, and knowing the resistance, R , we have this simple equation:—

$$M = \frac{E - CR}{n}$$

The induction curve of the G.E. 800 motor which I showed you last lecture, was obtained by the use of this equation. This is the most convenient way of finding the induction curve of a motor, namely, to run it at different speeds, observe the tension, the current, and the speed, and then deduce the induction factor.

Let us now consider the conditions under which this motor is running. You notice, in the first place, that it is running at what we call a uniform rate. Now what do we mean by that expression? We mean that there is a balance between the forces acting on the moving part of the motor, that is, the armature. These forces may be divided into two classes, first, those tending to assist the motion, and, secondly, those tending to retard the motion. When these two sets of forces are equal we get uniform motion. If they are not equal, for instance, if the forces retarding the motion are greater than those assisting the motion, then the motion will be retarded, and continue to be retarded until the motor finally stops. If on the other hand the difference is the other way, and the assisting forces are greater than the retarding forces, then the motor will go quicker and quicker, and it will continue to do so as long as that difference remains.

In the case before us, what are the actual forces acting upon this motor? The assisting force is the current of one ampere passing through the conductors of the armature, and we saw last week how to find exactly how much force that current produces. You have simply to multiply the current by 1.4 times the induction factor, and you get the measure of the assisting force. Now the retarding forces are those of the friction of bearings and brushes, hysteresis, &c. In this

case it is easy to find out exactly what the amount of the retarding force is. Since the current is one ampere and the induction factor 6.1, the retarding torque is 8.6 inch-pounds on the motor shaft; that is to say, when this motor is running uniformly at about 1,000 revolutions per minute, there is a perfect balance between the assisting force due to the current, and the resisting force due to the friction, &c.

In order to illustrate this more fully, I will describe briefly what happens when the load is changed. Of course we know that any increase in the load on the motor will have two results; it will reduce the speed and it will increase the current. What is going on in the motor during the interval of change of speed and current? When the motion was uniform we had a perfect balance between the assisting and the resisting force. When I put more load on I increase the retarding force. Of course I need not tell you what happens when the retarding force is increased. The balance is upset, and there is a resultant force tending to stop the motion. The motor runs a little slower, and the induced tension gets less.

Now $C = \frac{E - Mn}{R}$. Hence if n gets less C must increase, so that the result of increasing the load is to increase the current. Hence the motor will run slower until the current has increased to such an amount that there is again a balance between the retarding force, due to the load, and the assisting force, due to the current. We shall then again arrive at a condition of uniform motion, and this will continue until there is some further change in the load.

A similar process takes place if the load is reduced. It would be a difficult thing to reduce the load on this motor, because it has already as light a load as it can have, namely, that due to the friction of the bearings and brushes, and to hysteresis.

Here I want to explain that when I use the expression "load," I mean that which tends to retard the motion. You may express it in any way you like, either as inch-pounds of torque on the shaft or as the force at the rim of the pulley. But when I use the word "load," I mean the force that tends to retard the motion of the motor. Now, in this case the load is simply that due to friction, hysteresis, &c. When I put a brake on, the load is increased by the amount of the friction of the brake. We have already seen that for uniform motion we must have a perfect balance between

the assisting and the retarding forces. Now, the resisting forces are measured by what I have called the load; the assisting forces are measured—other things being the same—by the amount of current passing through the armature. It follows that for uniform motion the load determines the current. This is a deduction of very great practical importance. At first sight it may seem quite obvious that the only thing that determines the amount of current in the motor is the amount of retarding force on the shaft of motor. When, however, we come to consider the motor under different conditions, we shall find that it is not quite so obvious. I shall refer to some of these conditions later on, but for the present I simply

upon the load. Now let us see what this means. In the first place we see that for a shunt wound motor, in which the induction factor is constant, when the load is nothing the current is nothing, and the speed has a certain definite value, namely, the line volts divided by the induction factor. Directly we put a load on the motor the speed begins to fall off by an amount depending upon C , that is upon the load. We need not confine our attention to the case of motors in which the induction factor is constant. The most important class of motors for railway work is that of the series wound motor, in which the induction factor is not constant, but varies with the current in the motor.

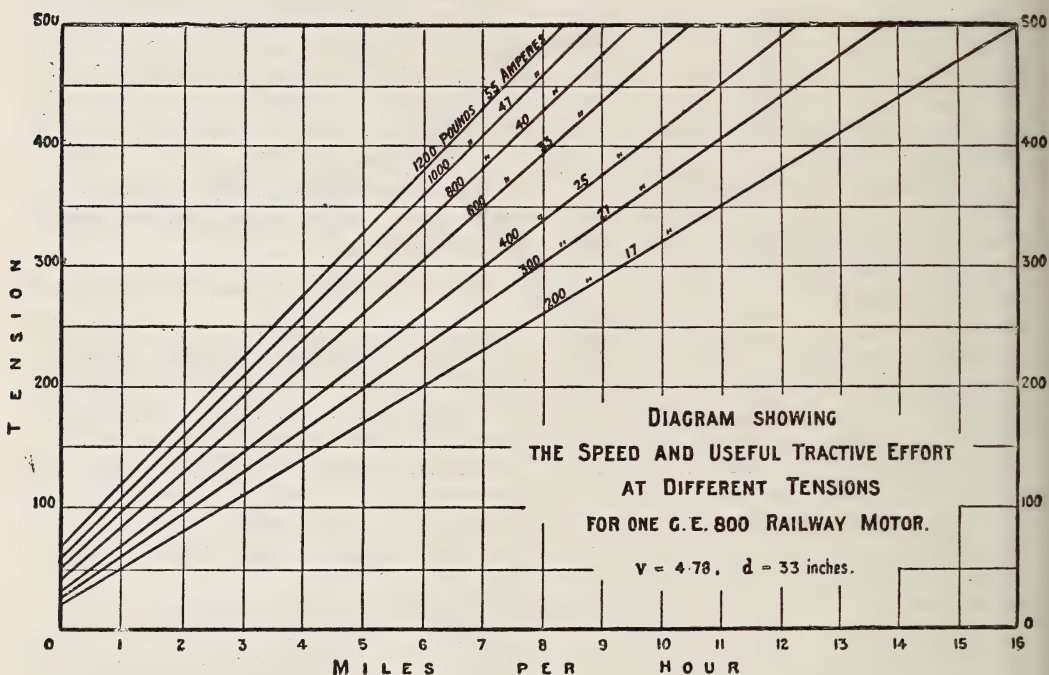


FIG. II.

want to emphasise the fact that when the speed is uniform, the current passing through the motor is determined by retarding torque on the shaft of the motor.

We know that n , the speed in revolutions per second, is equal to $\frac{E}{M} - \frac{CR}{M}$. This is

simply stating equation $C = \frac{E - Mn}{R}$ in

another form, and giving us an expression for the speed of the motor. We find that the speed of the motor is made up of two parts, one which depends upon E , the tension of the line, and the other upon C , which, in its turn, depends

I will illustrate this by some curves of the G.E. 800 motor that we were looking at last week. Here (Fig. II) is a diagram illustrating the way in which the speed of this motor, which is series wound, depends upon the tension of the line and upon the load. I have already shown you the induction curves of this motor in Fig. 3. The tension of the line in volts is set off vertically, and the speed of the car horizontally. These curves are drawn for an ordinary street railway equipment in which the maximum tension is 500 volts.

Let us take the case where the load on the motor is 800 lbs. Here is a curve which represents a load of 800 lbs. on the motor, *i.e.*,

the motor is exerting a horizontal pull of that amount. As long as the load is constant, any increase or decrease in the tension of the line affects the speed of the car, as shown by this curve; that is to say, looking once more at the equation for the speed, we have the load constant, and therefore the current constant, and the only thing we are varying is the tension of the line. If the tension of the line were to vary, say from 500 volts down to something under 50, the load meanwhile remaining constant, the speed of the car would vary as shown by the diagram. For instance, you see that for 500 volts the speed of the car is a little over nine miles an hour. If the tension drops to 200, the speed of the car falls to three miles an hour. As long as the load on the motor remains constant, the current remains constant, so that this diagram gives the variations of speed consequent upon variations in the tension of the line.

Let us now see what is the variation of the speed with the load, that is to say, let us keep *E* constant, and alter *C*. Suppose we have a car equipped with two of these motors, and suppose that the tension of the line is 500 volts, suppose also that the car is loaded in such a way that in order to move the car a draw-bar pull of 800 lbs. per motor has to be exerted. We should then find the car moving at the rate of a little over nine miles an hour. Suppose now that the car encountered a grade say of $3\frac{1}{2}$ per cent. If we assume that the car weighs 10 tons, there would be an increase of 50 per cent. in the load, that is to say, in order to move the car up the grade, we should require not only the 800 lbs. for friction, &c., but we should require 400 lbs. more for the grade, so that the load per motor would be 1,200. We see from the diagram that we should have to come on to this curve, and the speed would fall from 9.4 to something like 8 miles an hour. The tension on the terminals of each motor in this case is of course 500 volts if the motors were in parallel, and each motor would be taking 40 amperes in the first case and 55 in the second, so that the current taken from the line would be 80 amperes in the first case and 110 amperes in the second. Now we will suppose that 110 amperes is too great a current to be taken. Let us see what would happen if, when we come to ascend this grade, instead of putting the motors two in parallel we put them two in series. The fact of putting them two in series does not alter the current

per motor in the least, because the load per motor is just what it was before, and the current is, therefore, 55 amperes per motor; but since they are now both in series, the current for one motor also passes through the other, so that the current from the line is exactly halved, that is to say, 55 amperes.

By putting the motors in series, we have practically reduced the tension on the motor terminals from 500 to 250; consequently we see at once that the effect of putting the motors in series will be to bring us over on to the 250 volt line, and the speed will at once fall to about three miles an hour. This would be a very serious diminution in speed. Few street railway services would admit of such a reduction in the speed. We have, of course, as a set off against this disadvantage the fact that the current is reduced 50 per cent. by connecting the motors in series. In most cases it is found necessary to run the motors in parallel when ascending grades, even at the expense of taking a very large current from the line.

A short time ago I met with a very instructive illustration of this question of the current depending only upon the load on the motor. An electric street railway was being laid down in a town where there were several heavy grades. As soon as the line was opened, it was found that the armatures kept on burning out. The matter was carefully considered by the engineer, who reasoned as follows. He said:—"When a car is on a grade the load is so great that the drop in the leads is excessive; the result is that the tension at the terminals of the motor is very much reduced. Now, a certain amount of work has to be done in propelling the car, consequently if the tension is reduced, owing to the drop in the leads, we have to make it up in current; the result is that the motors take abnormally large currents when ascending the grades, and the remedy is to reduce the drop by putting in heavier leads." The engineer therefore telegraphed to the factory for a large supply of new feeders which were sent down at great cost, under the impression that by reducing the drop in the leads the tension on the terminals of the car would be increased, and the amount of current per motor would be diminished. You will, of course, at once see the fallacy of his argument. For a given load, the current per motor has nothing whatever to do with the tension, but depends only on the load.

Hitherto I have discussed only the question of uniform motion; I wish to draw your atten-

tion to the motor in the condition in which uniform motion is being gradually attained, that is to say, in which the motion is variable. And first of all let us make an experiment. I will take this motor in a state of rest. I will then send the current through the armature with the magnet circuit broken, as at *g* in the figure. I have now seven amperes passing through the armature of the motor; there is no motion because the magnets are not excited. I am going now to make the switch shown at *g* in Fig. 10, so as to send a current through the magnets. I want you to notice what takes place; the motor gradually speeds up from rest to a condition of uniform motion. I want you to notice particularly the time which elapses between the moment at which I make the magnet circuit, and that at which full speed is attained. Here we have an entirely new fact to deal with, viz., the question of the time it takes to get from a state of rest to a state of uniform motion. In order to make this a little more apparent, I will take off this wooden pulley and put an iron one in its place. Before I make the experiment with the iron pulley, however, I will repeat the experiment with the wooden pulley, so that you may clearly recognise the difference. We will take about six amperes, and I want you to judge in your own minds how long it takes from the moment I make this switch to the moment at which uniform speed is attained. It speeds up very quickly you see. I will now put on the iron pulley, and pass the same current through the armature. You see it takes a very much longer time to speed up.

Now let us see what is taking place here. Let us go back to the idea that we started with, that for motion of any kind we have two forces, those assisting the motion, and those retarding the motion. In this case what are the retarding forces? They are exactly the same as they were with the wooden pulley in all our former experiments, and they are measured by a current of 1 ampere passing through the armature. If you work that out you find that the forces opposing the motion in this case are equivalent to a force of about 3 lbs. acting at a radius of 3 inches.

Now what are the forces assisting the motion? At the moment of starting we had 6 amperes in the armature, and when the magnetic circuit is made we have, if you remember, $M = 6.1$, so that you can calculate at once what is the force at a radius of 3 inches. If you work it out you find that it comes to about 17 lbs. So that

you see we have two forces acting at a radius of 3 inches, supposing that the whole weight that is being moved is travelling in a circle 3 inches in radius.

The selection of a 3-inch radius is quite arbitrary. We may take any radius, but though the force will be altered, one result will be the same. I have taken 3 inches in this case because the weight of this pulley is practically concentrated at a radius of 3 inches. Here, then, is a very simple mechanical problem. We have a weight, which in this case is roughly about 30 lbs., travelling in a circle of 3 inches radius. We have two forces acting on this weight. We have, in the first place, a force of 17 lbs. tending to assist the motion, we have also a force of 3 lbs. tending to retard the motion; the result is a force of 14 lbs. tending to move the pulley. The motor will begin to turn, and its speed will increase. If we measure the speed by the motion of a point on the rim, in feet per second, the rate of increase of speed—which we will call *a*, the acceleration—is given by this equation:—

$$a = 32.2 \frac{T}{W},$$

where *T* is the difference between the assisting and the retarding force, and *W* is the weight. Putting $T = 14$, and $W = 30$, we see that in each second there is an increase of velocity of about 15 feet per second. All this is simply a mechanical question—there is nothing necessarily electrical about it.

Now we have here exactly what is going on in every car or train that is being driven by an electric motor. Suppose that the weight to be moved can be represented by a weight *W*, acting at a distance of *r* inches from the centre of rotation. If the pulley itself has no weight, we may suppose that a string is coiled round it and carried along, and attached to the weight of *W* lbs., which moves horizontally. The only difference is that the weight instead of moving round the circle moves in a horizontal line. That is simply another way of representing what goes on here. If I had time I could put on our wooden pulley and carry a cord from it to an arrangement of this kind, where a weight of 30 pounds could slide horizontally. You would see that we could get exactly the same motion that we have in this case. To get from this the case that we have in a railway, all we have to do is to suppose that instead of the shaft of the motor being fixed, the wheel rolls on a rail and that the weight acts at the centre of rotation. The

velocity of a point on the circumference of the wheel then becomes the velocity of the weight W along the rail. We have here then exactly the same conditions of motion as when we attempt to move a train or a car along a horizontal rail. If the total force acting on the train is represented by 17, and the retarding forces by 3, the force available for acceleration will be represented by 14, and the acceleration or rate of increase of speed will be given by the equation—

$$A = 32 \cdot 2 \frac{T}{W}$$

where T is here represented by 14.

I want to emphasise specially the fact that the rate of increase of speed, or the initial acceleration, can be made anything we like by simply adjusting the value of the current at the moment of starting. To illustrate this I will make another experiment. This rheostat, shown at h in Fig. 10, is in series with the armature. I have adjusted it so that when the motor is at rest, there is a current of five amperes passing through the armature. Directly I make the magnet circuit, the motor begins to speed up, and the initial acceleration depends upon the difference between the assisting and the retarding forces. The force retarding the motion is 3 lbs., but the assisting force depends upon the current, and that we can make anything we like by simply adjusting the rheostat. Now in this case I adjusted the resistance so that the current was six amperes, and, consequently, it started off with an initial acceleration of about 15 f.p.s. per second. If I adjust this rheostat so that the initial current, instead of being six amperes, is ten amperes, it will start very much quicker. The rate of starting up depends entirely upon the resistance in the circuit. You see that this entirely disposes of the popular impression that a heavy car or train "takes" a large current to start it. It does not of itself "take" any current at all. It takes just as much current as you choose to let it have, and the weight of the train does not make the least difference. The current that it takes at the moment of starting simply depends upon Ohm's law, *i.e.*, upon the value of the resistance that you choose to put in the circuit at the moment of starting. I have arranged this rheostat now in such a way that the current at the moment of starting is six amperes; on making the circuit it starts with an initial acceleration of 15 f.p.s. per second; if I increase the current by altering the rheostat I can make it start at 32 f.p.s. per second, so that there is no foundation at all for the impression that a

heavy train takes more current to start than a light one; you can make it take whatever current you like, but the rate at which it starts up depends on the amount of current.

As long as the difference between the assisting and retarding forces remain constant the rate of increase of speed remains constant. We can represent this graphically. I will take a line oa , as in Fig. 12, and another line, ob ,

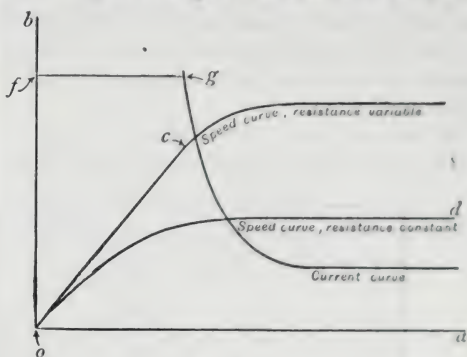


FIG 12.

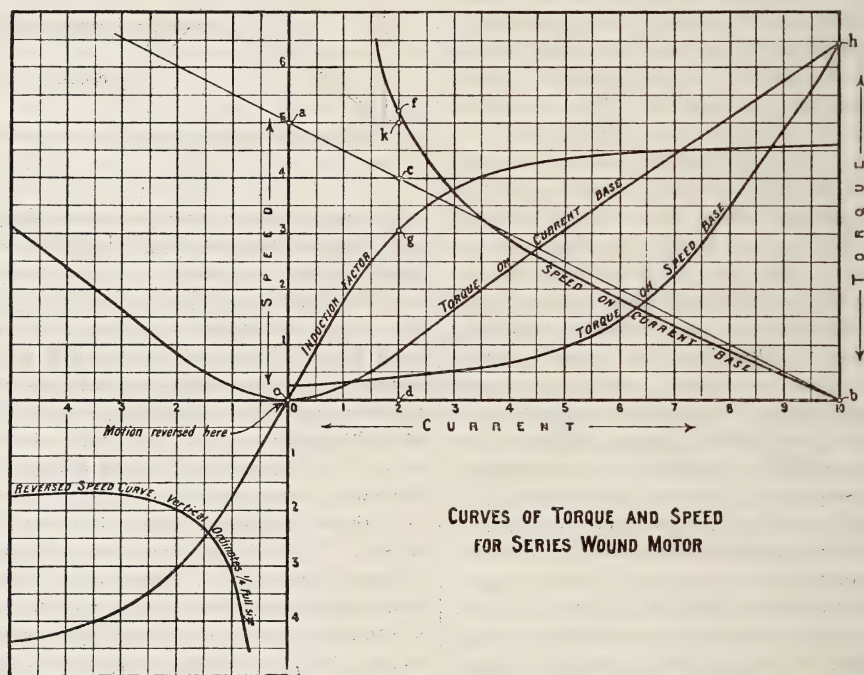
right angles to it, and measure along oa the time in seconds, and along the ob the speed in feet per second. Let us now represent in this figure the motion of a point on the rim of our pulley. As long as the difference between the assisting and the retarding forces remains the same, the acceleration will be uniform, and the line of acceleration will be straight, such as oc . You will see that in order that the assisting force should remain the same, the current must remain the same. Now does the current remain the same? Let us see. We will take a current of 6 amperes through the rheostat. Now when I start the motor by making the magnet switch, you will see that the current does not remain constant. Why does it not remain constant? Because directly motion begins, the motor on its own account begins to induce a certain tension, and that tension tends to stop the flow of the current through the armature, and we know that that tension is given by the product Mn ; so that the quicker the motor runs, the greater will be the induced tension, and the smaller the current in the armature. Directly motion commences, the current begins to get less. Instead of getting a line like oc , we get a line like od . That is to say, the acceleration instead of remaining constant, gradually gets less and less.

There is, however, a way in which we can maintain the acceleration constant, namely, by keeping the current constant. How can we do this? I will try to do it with this apparatus.

I will start off with six amperes, and what I want to do is to keep the ammeter pointed at six, as the motor speeds up, and if I can do that, I shall keep the acceleration constant. I have then to take the resistance of the rheostat out as the motor speeds up. It is clear that I can keep the current constant just as long as there is any resistance left in the rheostat. So that I am able to keep this line straight up to the point *c*, and as soon as the resistance is all out, the current begins to diminish, and the speed will increase until the final speed is increased.

Before we leave this diagram, I want to draw a curve on it, which shall represent the

of a series wound motor, such as is shown at *o g* in Fig. 13. From this induction curve we can determine the amount of the torque for all values of the current, so that we get a torque curve, such as *o h*, representing for any given current the value of the torque in inch-pounds. We can also get a curve, such as *b k*, representing for each value of the current the corresponding value of the speed. Having obtained the torque and also the speed for any current, we can at once deduce the torque for any speed, and we are thus able to draw a curve giving us the torque at different speeds. This curve is shown in Fig. 13 as "Torque on speed base," the speed in this case being measured



CURVES OF TORQUE AND SPEED
FOR SERIES WOUND MOTOR

FIG. 13.

variations of current. Let us represent along *o b*, not only the speed, but also the current in amperes. Let *o f* represent a current of six amperes; then the current curve will be given by a horizontal line up to the point *g*, when the rheostat is all out and the acceleration ceases to be constant. After this point the current rapidly diminishes until it finally becomes constant again, when the speed is uniform. We shall find later on that these curves of speed and current are of great importance and practical use.

I want now to explain briefly how the car attains finally a uniform speed. Let me draw our attention once more to the induction curve

horizontally in the figure. Let us see what this curve means. If we start at the point *b*, where the speed is nothing, the torque has its maximum value, *b h*; as the motor or car speeds up, the torque gets less, and the more the car speeds up, the less the torque becomes; until finally, in this case, the torque for high speeds becomes very small indeed.

In Fig. 14, we have a curve giving the torque at different speeds for a railway motor. The curve of total torque, *A*, gives us for any speed the corresponding value of the torque, the speed being measured horizontally, and the torque vertically from the point *o*. Curve *B* gives us the variation of the retarding forces

in the motor, also on a speed case. We find, in practice, that the force opposing the motion of a car or train are not constant—that it depends upon the speed. It is not difficult to determine how it varies with the speed. You will find that at the moment of starting the force opposing the motion is very great; after the driving wheels have made one or two revolutions it gets less and then generally increases again with the speed. Curve C is called the curve of accelerating torque, since it gives us the difference between the total torque and the retarding torque; that is to say, it tells us how much force is available for acceleration. It is obvious that where curve B cuts curve A, the accelerating torque must become nothing, and uniform speed will have been reached.

When we start up a car the total torque depends upon the amount of current passing in the motor, and the accelerating torque is equal to the difference between this and the retarding torque. As the car speeds up, the total torque gets less, and the accelerating torque also diminishes until, at the moment when the total torque is equal to the retarding torque, the force tending to assist the motion is nothing, and uniform speed will have been obtained.

To some minds this question of the starting of a car or train appears to be fraught with difficulty. One is sometimes confronted with the familiar dilemma that, if action and reaction are equal and opposite; if, for instance, the force with which the horse pulls on the traces of a cart is equal to the force with which the cart resists that pull, how do we get any motion at all? There are, as we have already seen, two distinct forces acting, one assisting and one resisting the motion. If the force assisting the motion at the outset is not greater than that resisting the motion the train cannot start. Unless we let enough current go through the motor to give a horizontal pull greater than the force which resists the motion, the motor will not start, but if we allow enough current to pass, so that the assisting force due to the current in the armature of the motor is greater than the resisting force due to friction, &c., then we get a resultant force available for accelerating; the train will begin to speed up, and the amount of the initial acceleration will depend upon the difference between the assisting and retarding forces at the moment of starting.

In conclusion, I will take the case of a train on the City and South London Railway, with which you must be familiar, and see how the

principles that we have been discussing apply there. I propose to try and predetermine what will happen when one of those trains is started.

We will take the tension of the line at 400 volts, and the weight of the train 35 tons. The driving wheels of the locomotive are 27 inches in diameter, and there are two gearless motors in each locomotive, which are connected permanently in series, so that there is a tension of 200 volts on each motor. The initial acceleration of a train under those conditions depends entirely on the amount of current that you allow to pass through the motor at the time of starting. The average current, as shown by experiment, is 150 amperes. What is the effect of passing this current through the motors? I have already shown you the induction curve of

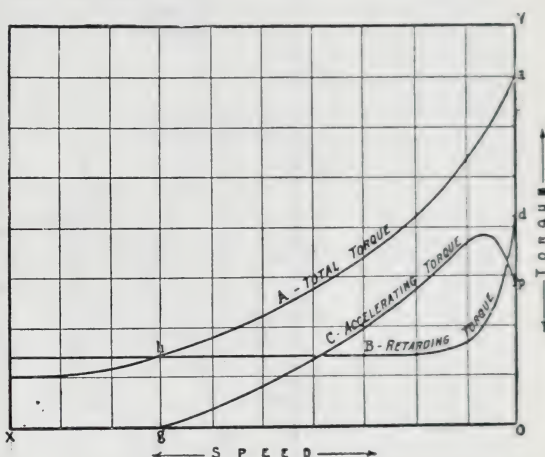


FIG. 14.

these motors, and if you look at Fig. 2, you will see that for 150 amperes the value of M is 63; you can then calculate what will be the value of the horizontal pull with wheels 27 inches in diameter. The total pull available for all purposes, will be 984 lbs. per motor. From experiment, we find that the force opposing the motion at the moment of starting is 426 lbs. Taking the difference between 984 and 426, we get a resultant of 558 lbs. available for accelerating. There are two motors, so that each motor has to accelerate half the weight of the train. You must now make use of the equation that I gave you for getting the acceleration, namely, $a = 32.2 \frac{T}{W}$, and we see that a is 0.46 f.p.s. per second, so that if this acceleration remained constant for 40 seconds,

the speed of the train at the end of that time would be about 18 feet per second. The current will be kept constant as long as there is any resistance left in the starting rheostat. Directly the starting rheostat is all out, the current will diminish in the way you saw on the ammeter in our experiment, and the acceleration will cease to be constant, gradually getting less and less until finally uniform speed is attained. This acceleration curve may be constructed by a graphic method when you have the induction curve of the motor.

You may remember that not long ago acceleration curves of the trains for the new Central London Railway were published, predicting the action of the locomotives to be used on that railway. I was interested to see in one of the technical journals a laugh raised against the makers of these locomotives because they ventured to predetermine what they were going to do. Now if we have the profile of a line, the resistances to motion and the induction curve of the motors, we can predetermine with remarkable certainty the shape

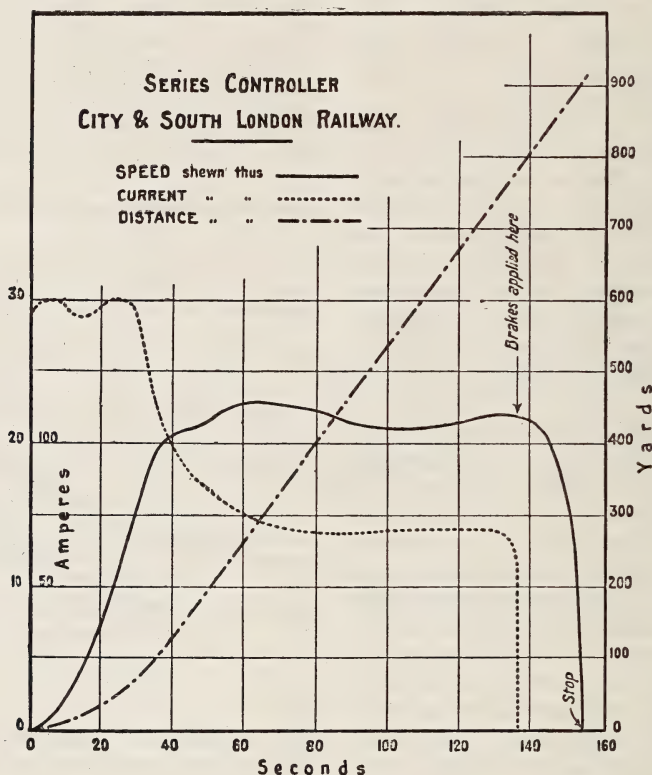


FIG. 15.

Fig. 15 gives the actual result as obtained by experiment. The starting current is 150 amperes. You see the acceleration is held practically constant for very nearly 40 seconds, and at that time the speed of the train is 20 feet per second—very nearly what it was by calculation. Directly the rheostat is all out the current begins to decrease very rapidly, and the acceleration soon becomes constant. At the end of 137 seconds the current is cut off, the brakes put on, and the car comes to a standstill in 152 seconds.

of the acceleration curve. There is no other method of locomotion in which you can predict in that way what a train will do; steam engineers have not yet obtained that knowledge of the action of a locomotive that would enable them to predetermine their acceleration curves in this way. When, therefore, you see the diagrams of acceleration of a line such as the Central London Railway predetermined, you must not suppose that the makers of those motors are talking about what they do not understand.

Miscellaneous.

THE APPLICATION OF THE ELECTRIC MOTOR TO SMALL INDUSTRIAL PURPOSES.*

The electric motor is rapidly becoming the most favoured medium for the transformation and transmission of energy for all industrial operations whether on a large or a small scale. This is due to the paramount advantages it possesses over any other method of utilising potential energy. These advantages are well known to electrical engineers, but indifferently appreciated by a large number of mechanical engineers, and almost unknown by the general manufacturer and tradesman. To the last of these three, the general manufacturer and tradesman who is using machinery driven at present by steam or water power, the electric motor must in the days to come prove of exceptional value; and yet, strangely enough, very little effort has hitherto been made either by the motor maker or by the managers of electricity supply undertakings to open up this very wide and lucrative field of enterprise. There is no necessity to enumerate here the many excellent and distinctive features which the electric motor possesses. The intention in this paper is rather to consider the reasons why its application up to the present time has been confined to a few special trades and manufactures. We are familiar, for instance, with electrically-driven pumps, electric hoists and cranes, electrically-driven machine tools, and electric power transmission in works—cases in which the generation, transformation, and application occur practically under one roof. Many manufacturers and constructional engineers, wisely and readily incurring additional capital outlay with the object of securing more economical production, have adopted electric motors, which do not entail the use of endless and power-absorbing shafting and countershafting. As yet, however, it cannot be said that the electric motor is in general use, or scarcely other than just past the threshold of its future domain.

The smaller producer and tradesman, to whom motive power in some form or other is essential, and who feels more acutely than his larger *confrère* the effects of competition, has, in the great majority of cases, still to put up with very much more cumbersome and very much less efficient means of power production. Almost every town with any pretensions to size and importance has its own large staple industries as well as many minor industries and businesses, requiring the use of other power than hand power. There are also some handicrafts which are at present unavoidably confined to hand power,

because steam, gas, oil, and hydraulic power are each and all inapplicable. There can be little doubt that the electric motor would be welcomed and readily adopted in these cases if only its simplicity and adaptability were known and understood.

The chief obstacle to the more rapid adoption of electric motive power, especially in the case of small tradesmen, throughout the country is undoubtedly the want of capital to purchase the necessary motor; but where the power to purchase exists, the buyer will probably have little or no experience or knowledge of electrical matters to guide him in his purchase; if his means are at all limited he will be tempted to venture on a cheap line, and become the dupe of those who simply make to sell. The solution of these difficulties is that the owners of electricity supply undertakings, whether a public company, municipality, or other local authority, should themselves purchase good, reliable motors, and let them out on hire. Antecedently this scheme may appear a sort of parental *régime*, but it is suited to present circumstances at any rate, and experience proves it to work well. Unfortunately, all local authorities have not got powers to borrow money for this purpose, although it appears from the Electric Lighting and Public Health Acts that borrowing powers may be granted by the Local Government Board for works of a permanent nature. Electric motors do not yet come within that category, although gas-stoves do, a legal decision having been given in their case. All future municipal Parliamentary Bills should therefore contain clauses which would confer such powers and secure freedom of action in this respect. In Bradford a rental charge of 10 per cent. upon the initial cost of each motor has been found to be amply sufficient. This is made up of 3 per cent. for interest, 3 per cent. for sinking fund, and 4 per cent. for depreciation and contingent expenses. The Bradford Corporation inaugurated their scheme of hiring (in which also arc lamps are included on similar terms) in November, 1896, and it was found that the increase in electricity supplied for motive power in 1896, in which year the hire system had been in operation for two months only, was 19,053 units; in 1897 the increased sale over 1896 was 52,204 units; and in the present year the increase is likely to be 62,834—or a sale of 180,000 units, or 53 per cent. over 1897.

Hitherto the supply has been confined to small power uses—such as cranes, hoists, fans, pumping, aerated water making, electric advertisement signs, and similar purposes. During the last month, however, so popular has the electric motor become that applications have been received from a large spinning and weaving firm, two foundries for blower purposes, an engineering shop requiring 50 h.p., and a saw mill requiring about 20 h.p. I referred a moment or two ago to the want of confidence of the small power user in the electric motor; that confidence, however, is soon gained. It is gratifying to be able to state that several consumers in Bradford who originally applied

* Abstract of paper read before Section G (Mechanical Science) at the meeting of the British Association at Bristol, by Alfred H. Gibbings, M.I.E.E.

on the hire system, and at the time with much trepidation and many inquiries, have since decided to purchase the motors outright.

DR. RUSSELL'S PHOTOGRAPHIC RESEARCHES.

At the recent meeting of the British Association at Bristol, Dr. W. J. Russell gave (before the Chemical Section) some further information as to his recent researches on the action exerted by certain metals and organic substances on photographic plates. In recent communications to the Royal Society and the Camera Club, Dr. Russell has shown that a picture can be obtained on a sensitive photographic plate in total darkness—that is, that by other means than light the film can be so acted on as to get a picture by submitting the film after exposure to treatment identical with that to which the light pictures are subjected. The material, metallic or otherwise, to be tested was placed over a sensitive plate either in contact, or with an intervening screen of air or some other material, or the order was reversed and the sensitive plate placed above; the period of leaving in this position varied from a few hours to a week, according to circumstances, the time being less with more active substances, with the proximity of the object to the sensitive plate, and with increase of temperature; there is, however, a limit to the temperature that can be employed in practice—namely, about 55° C. Printing ink was shown to be very active in the sense indicated. Some ordinary type, a portion of the cover of *Punch*, and the wrapper of a packet of tobacco had been submitted to the test, and had reproduced strongly-defined pictures; the last mentioned was particularly interesting, inasmuch as the red ink had proved active, the blue inactive. Strangely, writing ink (old-fashioned) is quite inactive, and paper having writing on it in ink, even over a hundred years old, when placed between a sheet of active material and a sensitive plate yielded a picture in which the writing appeared quite distinctly, white on black, in spite of the original being in some cases indistinct; ferrous sulphate behaves like ink. The list of materials that are active is very long, and includes wood, which gives a picture of the grain and knots. Many metals are active, but zinc is very active only when bright, so that a dirty sheet of zinc rubbed with sand paper gives a picture of the scratches. Many alloys are also active, pewter and fusible metal being two of them, and curiously some brasses are, whilst others are not. The effective agency that passes from the material to the sensitive plate shows peculiarities. It passes through gelatine, gutta-percha, celluloid, collodion, wet gum arabic, and some paper, whilst other paper, glass, minerals transparent to light, and many other substances are opaque to these emanations, and some striking effects were exhibited demonstrating the interference of these opaque substances when interposed between an active sub-

stance and the sensitive plate. For instance, a five pound note placed printing downwards on the sensitive plate gave a picture of the printing inscription, but when placed under a zinc plate with the printing towards the zinc plate it gave a picture of the opaque paper with the water marks distinctly showing, and what is still more astonishing, the zinc plate, after contact with the note, itself yielded a picture of the inscription, showing that the influence from the ink had passed to the zinc plate. It was noteworthy that the signature was not in writing ink. A cutting from the *Times*, the paper being transparent, showed a picture of the printing on both sides; the picture, moreover, was reversible, showing that a perfect picture of both sides of the paper had been impressed on the one plate. This interesting phenomenon, is however not quite explained, but the great amount of work he has done leads him to the provisional opinion that the effect is due to the evolution of hydrogen peroxide.

Obituary.

JEREMIAH JAMES COLMAN.—Mr. J. J. Colman, who died at Lowestoft on the 18th inst., had been a member of the Society of Arts since 1855. He was the head of the well-known firm of Messrs J. and J. Colman, mustard, starch, and blue manufacturers. He was born in 1830, and was the only son of Mr. James Colman, of Stoke Holy Cross, Norwich. From 1871 till 1895 he represented Norwich in Parliament. He was mayor of Norwich in 1867-8. He was a well-known agriculturist and breeder of stock, and took many prizes at the Smithfield, Royal, and other shows.

General Notes.

ST. PETERSBURG HORTICULTURAL EXHIBITION.—Information has been received from the Foreign-office, through the Department of Science and Art, that a Horticultural Exhibition will be held at St. Petersburg in May, 1899.

FRENCH INSTITUTIONS DE PRÉVOYANCE.—It is announced that the Association des Institutions de Prévoyance of Paris proposes to celebrate in 1900 the twenty-fifth anniversary of its foundation, by holding a special meeting, at which the Permanent Secretary (Mons. de Malarce) will present a report on the history of the Institution, and the work which has been done during the twenty-five years of its existence.

Journal of the Society of Arts.

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FRIDAY, SEPTEMBER 30, 1898.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****EXAMINATIONS, 1899.**

The dates fixed for the Society's Examinations in 1899 are Monday, March 13th, Tuesday, 14th, Wednesday, 15th, and Thursday, 16th.

The Programme of Examinations is now ready. Copies of the Programme, with full details, and an Appendix containing last year's questions and reports by the Examiners, can be had, price 3d., post free, on application to the Secretary, Sir Henry Trueman Wood, Society of Arts, Adelphi, W.C.

Proceedings of the Society.**CANTOR LECTURES.****ELECTRIC TRACTION.**

BY PROF. CHARLES A. CARUS-WILSON.
M.A., M.Inst.E.E.

Lecture III.—Delivered May 16, 1898.

We saw last week that when a motor is connected to a line of constant tension, it speeds up from rest according to a definite law, and that if the resistance of the motor is unchanged in the process, the rate of speeding up, that is to say, the acceleration, has a certain definite initial value that can be easily calculated, and then gradually diminishes, the time required to attain full speed depending chiefly upon the moment of inertia of the mass that has to be set in motion.

We saw also that if we are able to vary the resistance in the circuit, by means of a rheostat in series with the armature of the motor, we can keep the acceleration constant for a considerable period, for so long, in fact, as we can keep any resistance in circuit, and that when the rheostat is "all out," the acceleration begins to diminish as it does in the case already considered where the resistance is constant

We have now to see how the principles that have been shown to hold when a motor is speeding up from rest may be applied to the practical case of controlling the action of a motor or motors.

Before taking up the question of control in its practical aspects, let us devote a few minutes to considering two important ways in which the curves of acceleration and current may assist our future discussion.

Referring to the diagram given in Fig. 12, and confining our attention for the present to the curve of acceleration with variable resistance, let us suppose that we draw a line parallel to the speed axis, that is to say, a vertical line, cutting the acceleration curve at any point. Now vertical distances represent speeds in feet per second, and horizontal distances represent time in seconds, hence any area enclosed between the curve and such a vertical line as we have drawn, will represent the product of feet per second and seconds, that is to say, feet. It follows that when we have the curve of acceleration, representing the way in which a car or train speeds up from rest, we can find the distance in feet that will have been covered in any given number of seconds from the moment of starting, by drawing a vertical line through the point in the time base corresponding to the given time, and finding the area included between that line, the curve and the time base. For instance, if we have to compare the distance travelled in so many seconds from the moment of starting by the two methods of constant and variable acceleration, as shown by the acceleration curves in Fig. 12, we can do so at once by drawing a vertical line at the proper point on the time base, and comparing the areas included between this line and the two acceleration curves. A simple inspection shows us that the distance covered by the constant acceleration method is greater than that of the variable acceleration.

If we draw a number of vertical lines at different times, and find by this method the distance travelled at each time, and set off a vertical length along the line previously drawn on some suitable scale, we shall get a curve giving us the distance travelled at each time. Such a curve has been drawn in Fig. 15, giving the performance of the motors on the City and South London Railway. This new curve turns up rapidly after full speed has been attained. It is easy to see that so long as the acceleration is constant, the distance travelled increases as the square of the time,

the distance curve therefore being a parabola, and that directly the acceleration ceases, and full speed is attained, the distance covered increases simply as the time, so that the distance curve becomes a straight line.

Turning our attention now to the current curve, we have seen that while horizontal distances represent seconds, as in the acceleration curve, the vertical axis measures current in amperes. Hence the area of the current curve represents the product of amperes and seconds. Now the tension of the line is constant, therefore the area of the current curve represents ampere-seconds multiplied by volts, that is to say, watt-seconds, or, more simply, work done. If then we have the current curve giving the variations of the current used in starting a car or train, we can find out how much work has been done in starting, by drawing a vertical line through the given point on the time base, and finding the area of the current curve included between this line and the current curve, expressed in watt-seconds or foot-pounds, or any other convenient unit of work. We shall find that we often have occasion to compare the work done in covering a given distance, or in getting up a given speed, by different methods of control, and we shall be able to effect our comparison most conveniently by comparing the areas of the current curves.

Let us now consider the simplest case of motor control, namely, that where there is one motor only. First of all, we are met by the difficulty that if we suddenly switch on a motor at rest to a line of any considerable tension, we shall have so large a current passing through the armature that we shall inevitably blow the fuse inserted in the circuit to protect the motor from injury. It is obvious, therefore, that we must either make the resistance of the motor sufficiently large, so that when thrown on the line, the current, as given by Ohm's law, does not exceed the safe limit, or else we must have a rheostat in series with the armature, which may be gradually removed as the motor speeds up. The question then arises, "Would it not be simpler to do away with the rheostat, and have all the resistance in the motor itself?" There are serious objections to such a method. In the first place the C^2R losses, which are so large a part of the losses incurred in starting, are increased directly in proportion to the resistance in the circuit. I think we should be all ready to admit that from the point of view of economy of running a high internal resistance is objectionable.

There is, however, another reason why a high internal resistance should be avoided. The speed of a motor may be expressed by

the equation $n = \frac{E - CR}{M}$ where C is the current required to balance the load on the motor.

Now if the speed at full load is fixed, a motor with a high internal resistance must have a proportionally small induction factor. Hence the torque for any given current will be smaller for the motor with the higher internal resistance, so that at the moment of starting the torque available for acceleration will be less. Now I am not bringing this point to your notice simply for the sake of the theoretic interest involved. It is a matter of distinct practical importance.

By way of illustration I may quote the case of the motors which were designed to run on the Liverpool Overhead Railway. The first motors that were designed for this railway were made with very high internal resistance, as much as 1.04 ohms, including the armature and the magnets, the motors being series wound. The object of making the resistance so high was stated to be to get as much as possible of the starting resistance in the form of convolutions on the armature, for then, it was said, the resistance that would otherwise have to take the form of a rheostat, might be made use of to get a greater torque at the moment of starting.

Now these motors had to comply with a certain specification, which stipulated that they should give a definite horizontal pull at a given speed. Under these conditions the induction factor is smaller in proportion as the resistance is greater. In this particular case, the induction factor for 100 amperes in the magnet winding was 172, and the horizontal pull on 33-inch driving wheels was 1,460 lbs.

If the internal resistance had been reduced, say to 0.39 ohms, the induction factor might have been increased to 184 for 100 amperes; giving a horizontal pull of 1,560 lbs. for 100 amperes; these motors would thus give the specified pull at full speed, but nearly 7 per cent. more pull for 100 amperes; so that the increase in the internal resistance so far from increasing the tractive effort at the moment of starting, actually decreases it.

It thus appears that it is important to reduce as much as possible the internal resistance of the motors. We are therefore obliged to use a starting rheostat of such a resistance that, when placed in series with the motor at rest, the current may not exceed the safe limit. It

is easy to determine what the resistance of the first step of the rheostat must be. Suppose that the safe current is fixed at 60 amperes, and that the tension of the line is 500 volts; the total resistance in the circuit at the moment of starting must then be 8.34 ohms, so that if the resistance of the motor itself is, say, 1 ohm, that of the rheostat must be 7.34 ohms. As the motor speeds up, this resistance may be taken out, the current meanwhile being kept constant at 60 amperes. During this process the acceleration will be constant. If we

running at equal speeds, and the loads on the motors will be equal.

There are three possible methods. The motors may be run permanently in parallel, so that each motor will act as a single motor controlled with its own starting rheostat in the way we have just been discussing. Secondly, the two motors may be connected permanently in series, and controlled with a single rheostat. Thirdly, the motors may be connected first in series and then in parallel. I propose briefly to discuss these methods and to compare them.

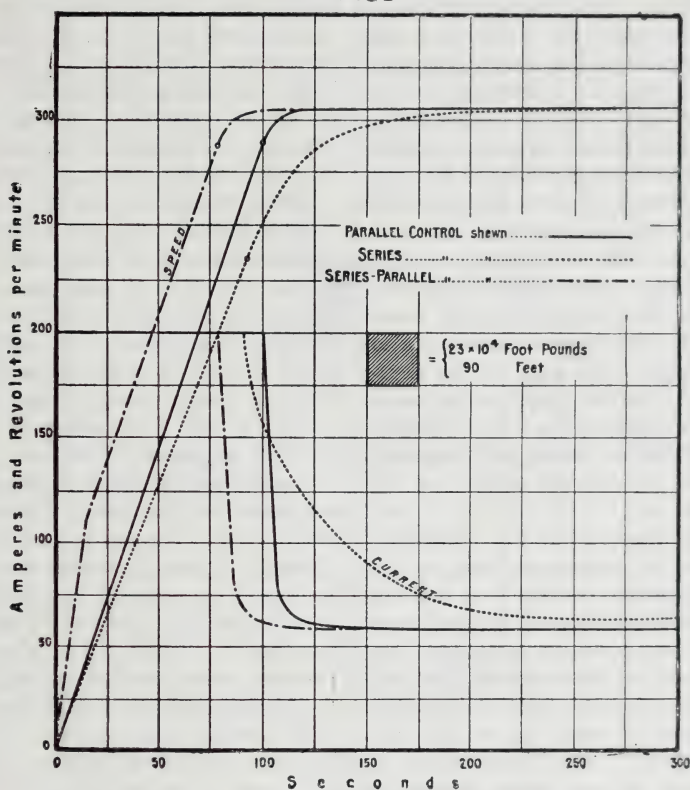


FIG. 16.

know the induction factor for 60 amperes, we know the total horizontal pull with driving wheels of given diameter. If we know the resistance to motion, we can deduce the tractive effort available for acceleration, and hence the acceleration. When the starting rheostat is "all out," the motor will speed up by itself, and the current rapidly diminish in the way we have already seen.

We now come to the case where we have two motors to deal with, as for instance in a railway car. The two motors will of course be

To fix our ideas let us take a definite instance. Suppose that we have a railway car weighing 40 tons, and that it has to travel at 30 miles an hour, the resistance to motion at that speed being expressed in terms of torque at the main driving axles, and equal to 200 inch-pounds per ton of load. Suppose, further, that the driving wheels are 33 inches in diameter, that the motors are gearless, so that the velocity ratio is unity, that the tension of the line is 500 volts, and the internal resistance of each motor 0.4 ohms.

Confining our attention, in the first instance, to the case where the two motors are to be connected in parallel throughout, we find that in order to drive the car at the specified speed with the given resistance to motion—the latter being equivalent to a horizontal pull of 242 lbs. per motor—the induction factor must be 96, and the corresponding current 30 amperes.* If the current from the line is limited to 200 amperes, the current per motor, when the two are in parallel will be 100; assuming the frictional resistance to motion to remain the same at all speeds, we shall have 70 amperes available for acceleration. Now each motor has to accelerate 20 tons, hence the acceleration will be 0.41 f.p.s. per second. The starting rheostat must have a resistance of 4.6 ohms on the first step, and the current of 100 amperes per motor can be held constant for 100 seconds. At this point the speed of the car will be 41 feet per second, and the distance travelled 2,075 feet.

The form of the acceleration curve is shown in Fig. 16. The acceleration is constant up to 41 f.p.s., the starting rheostat here all out, and the full speed of 44 f.p.s. is soon reached. The current curve is also shown in this figure. As soon as the rheostat is all out the current begins to diminish very rapidly; the current given in the figure is that required for the whole car, including both the motors, so that the current at full speed is 60 amperes.

If we consider the car to be "started" when a speed of 29.5 miles per hour, *i.e.*, 43 f.p.s., has been attained, we see that this will have been accomplished in 107 seconds from the moment at which motion commenced. By finding the area of the current curve up to this point, we ascertain that the total consumption of energy required to start the car by this method of control is 753×10^4 foot-pounds.

We now come to the case where the motors are to be connected throughout in series. In comparing this case with the first, we see that the tension at the terminals of the motors is now only 250 volts. In order to make up the specified speed the induction factor must be much lower, the calculated value being 44. The current per motor is now 200, the full current from the line. The current required to overcome friction is 64 amperes, leaving 136 amperes for acceleration; the acceleration is 0.37 f.p.s. per second, the rheostat is all out in 91 seconds and the speed is then 33 feet per second. The car will be "started" in 160

seconds, and the energy required to start is 972×10^4 foot-pounds.

The acceleration and current curves for this method of control, are shown in Fig. 16, so that the behaviour of the car may be compared with that with the parallel method of control. The difference in the form of the current curves is very marked, and fully accounts for the large increase in the energy consumption with the series method. The starting rheostat is "all out" at a much lower speed, and the motors take much longer to attain the final speed than with the parallel method. The final current is also larger, being 64 amperes, as compared with 60 for the parallel method. Altogether, we see that this method compares badly with the parallel method of control, as far as the question of starting is concerned, and that it is rather less efficient at full speed for equal ohmic resistances in the motors.

In the locomotives on the City and South London Railway, the motors are permanently connected in series. Diagrams of current and acceleration have already been shown you in Fig. 15. Those of you who wish to go further into this subject than is possible in so short a course of lectures, would do well to read carefully the paper giving a description of this railway in the "Proceedings of the Institution of Civil Engineers," vol. cxii., and also an account of the Liverpool Overhead Railway, in vol. cxvii. of the same Proceedings. The point to which I invite you to give the closest attention, is the discussion that followed the reading of the papers. You will there see that the question was raised as to which were the more efficient locomotives, those used on the City and South London Railway, or those on the Liverpool Overhead Railway.

The test of efficiency was held to be the horizontal pull exerted by the locomotive for a given current, 100 amperes, from the line. This was quite reasonably taken as a fair basis of comparison, since the total horse-power of the locomotives was nearly the same in the two cases. When, however, the actual figures were quoted, it appeared that one of the Liverpool motors could pull over two of the South London motors when equal current was passing in all three. This was taken as conclusive proof that the Liverpool motors were the best. A leading engineer told me subsequently that he had actually seen the experiment made, and that it convinced him of the superiority of the Liverpool motors.

In reading the report of the discussion, you should note the confusion of thought present

* See page 55 of the Author's "Electro-Dynamics." Longmans, Green and Co.

in the minds of many who took part in it. The question at issue was the efficiency of the *locomotives*, but the test submitted was the hauling strength of the *motors*. Now, the Liverpool locomotives had each two motors designed to drive the train at full speed when connected in parallel, while the South London motors had to drive the train at full speed in series. From what you have seen, you will at once recognise that the induction factor of the

connected motor would give 2.18 times the pull of one series connected motor.

You see then that the pull exerted by each motor is no criterion of the efficiency of the locomotive as a whole, because with 100 amperes from the line the current per motor in the Liverpool motor would be half that in the London locomotive, so that the total pull exerted by the locomotive would be nearly the same.

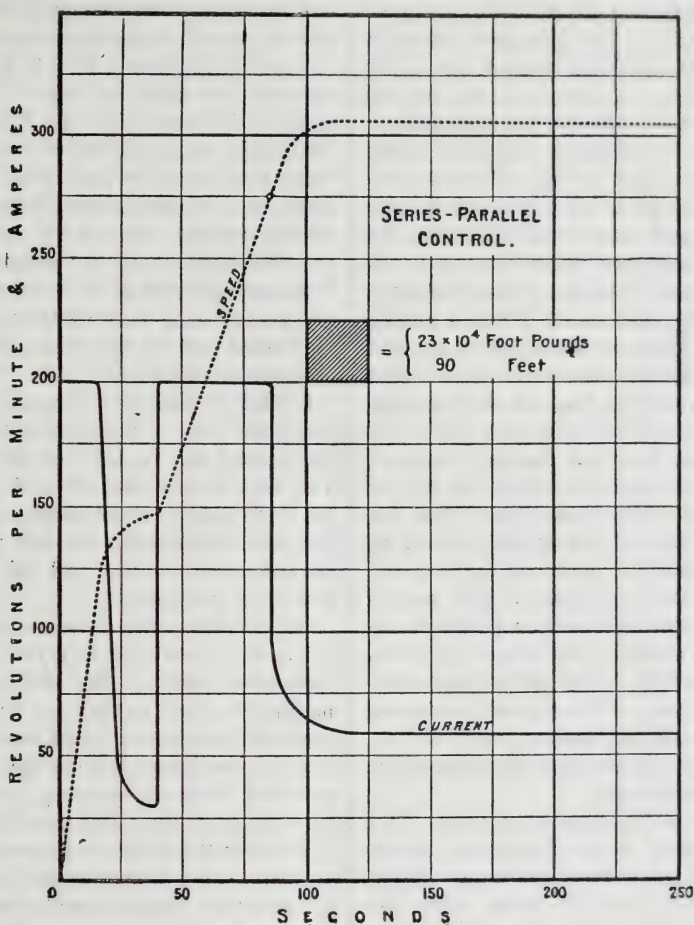


FIG. 17.

Liverpool motors must be more than twice that of the South London motors, so that for equal current per motor, one Liverpool motor must give more than twice the pull of one London motor. The case is, in fact, identical with that which we have just been discussing, for you saw that when all other conditions were the same, with the data we assumed, the induction factors were 96 and 44 respectively, so that for equal current per motor one parallel

The matter was still further complicated by the fact that the diameter of the driving wheels was not the same in the two cases, being 33 inches on the Liverpool locomotives, and 27 inches on those of the South London line. This would give an advantage to the latter, and would oblige us to make a correction if we wished to obtain accurate results of the comparison.

I must now ask you to follow me into a brief

description of the third method of control that we have to consider, namely, that of the well-known "series-parallel" arrangement. In this method the two motors are started in series, and subsequently thrown over into parallel connection.

I shall take the same data as in the other two cases. You see that since the car has to move at full speed with the motors in parallel, the induction factor must be the same as in the first case, namely, 96. But now we have a striking difference from either of the two cases considered already. The induction factor is the same as in the parallel method, but at the moment of starting the current is the same as in the series method, namely, 200 amperes per motor. The total torque is, therefore, much greater than in either of the other methods, and the acceleration is as much as 1.0 f.p.s. per second, nearly three times that with the series method, and more than twice that with the parallel method. This is a great advantage, and if it could be maintained it would enable us to effect an immense saving, both in time and energy. We can, however, maintain this state of affairs, only so long as we can keep the current constant at 200 amperes. We shall, of course, have our starting rheostat, and the resistance must be taken out as the motors speed up. Calculation shows that the resistance will be all out at the end of 15 seconds, and that the speed of the car will then be only 15 feet per second. The motors must then be switched over to parallel connection, with sufficient resistance in series with each motor to keep the current per motor down to 100 amperes. The car will then speed up as in the parallel method, and will be "started" in 87 seconds with an expenditure of 605×10^4 foot-pounds.

These results are plotted in Fig. 16. This method is evidently better than either of the others, the gain being made on the step during which the motors are in series with one another. This step, however, lasts only for 15 seconds, so that the advantage of the series-parallel method of control is limited by the time during which the motors can be held in series connection.

We might have allowed the motors to speed up as much as possible while connected in series. The car would then attain a uniform speed of 17 miles an hour, and we might throw the motors over into parallel connection at any moment. Fig. 17 gives the current and acceleration curves that we should get in such a case. The notch in the current curve

shows where the motors are speeding up in series.

There is a practical objection to allowing the motors to speed in series. The acceleration of the car on the parallel step is, as we have seen, 0.41 f.p.s. per second. Now, if the car is allowed to attain a uniform speed with the motors in series, there will be a sudden shock when the motors are thrown over into parallel connection. This shock may be frequently observed when the motor-man on a car equipped with a series-parallel controller does not switch over to parallel at the right moment.

You will readily see how to find the proper moment for switching over. It must take place so that there is no shock, *i.e.*, so that the change in the acceleration is gradual. The motor must therefore be allowed to speed up in series until the acceleration is the same as that on the parallel step; if the motors are then thrown over there will be no shock. In Fig. 17 if the straight part of the acceleration curve on the parallel step were drawn as a tangent to the curved part on the series step, we should obtain the same result.

I think it will be obvious to you that the longer the motors are allowed to run in series the greater will be the loss of time involved. The best results are attained if the motors are thrown over without shock; in the case we are now considering the car would then be started in 80 seconds, with an expenditure of 562×10^4 foot-pounds.

Fig. 18 shows the distance travelled by the car in any given time with the three different methods of control. For short runs the series parallel method enables us to cover much greater distances in a given time than either of the other methods; but as the distance to be travelled becomes greater, the proportional advantages of the series-parallel diminishes.

There is one way of connecting the series-control that I have not alluded to. If, instead of taking 200 amperes per motor on the series step we had taken only 100, the current from the line would have been halved during the process, and the current per motor would remain the same throughout. The acceleration would thus be the same on both steps, and the distance covered in a given time would be the same as with the parallel method. The advantage of this way of connecting up a series-parallel controller is that there is a large saving of energy on the series step, and the motors have to carry only half the maximum current required by the method described previously. In cases where the whole distance

travelled is very short, and the brakes have to be applied very soon after, or even before, full speed is attained, the advantages just enumerated outweigh the benefit gained by passing twice as much current through the motors during the series period.

The action of the controller on the City and South London line is well illustrated in Fig. 15,

which they are thrown over into parallel. More accurate observations would, no doubt, show that the curve during the series connection was not so straight as shown in the diagram.

I shall now show you some diagrams which will give you a good idea of the action of a car during the process of getting up speed and the

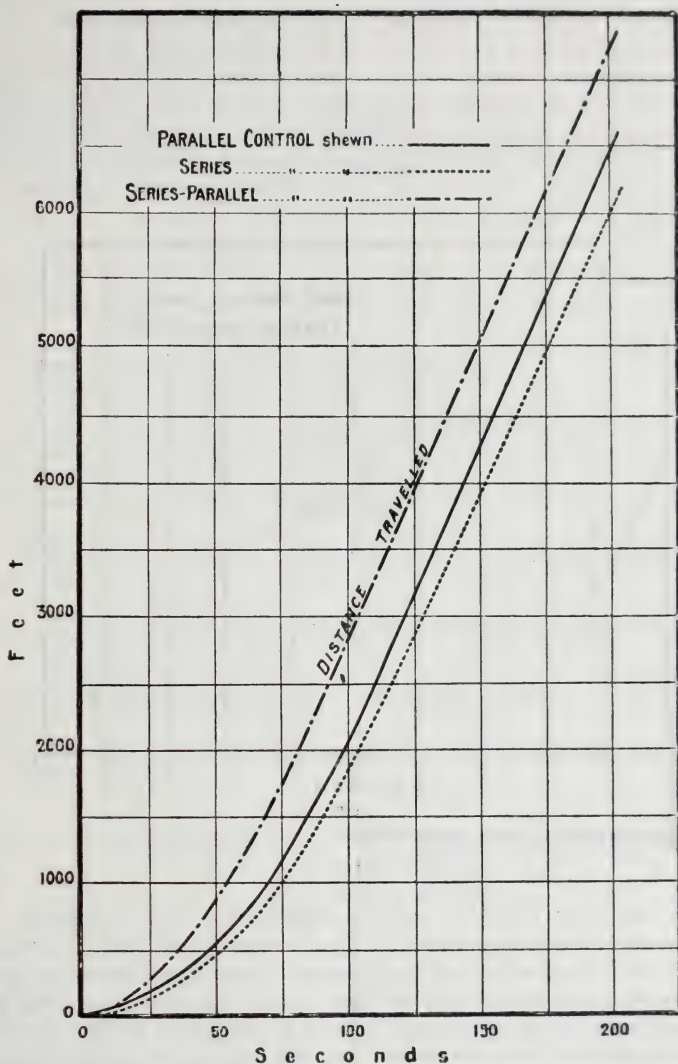


FIG. 18.

which I have already shown you. The starting rheostat is held in for nearly 30 seconds. The form of the current curve as the motors speed up is well shown.

Fig. 19 gives the current curve obtained on the Liverpool Overhead Railway. The notch in the curve represents the period during which the motors were speeding up in series, after

way in which that action is modified by different methods of handling the controller.

The curves in Figs. 20 and 21 are the results of experiments made by my friend, Mr. H. P. Curtiss, on the Buffalo and Niagara Falls Electric Railway. They are I believe amongst the best if not quite the best curves of the kind ever obtained. A full account of the way in

which the experiments were made may be found by any of you who wish to look further into the matter in the "Street Railway Review" for July, 1896.

The cars used in the experiments weighed 13.6 tons, and were 36 feet in length. There are four driving wheels, each equipped with one G.E. 800 motor; I have already given you the induction and other curves of this motor. The wheels are 33 inches in diameter, and the velocity ratio 4.78. The tension of the line in the experiments was 550 volts.

In both figures the vertical ordinates give speed in feet per second for the acceleration curves, and total current from the line in amperes for the current curves. Fig. 20 is the

and the sudden rise in the acceleration curve after uniform speed has been attained indicates the jerk to which the whole car was subjected when the motors were thrown over to parallel connection. An inspection of the curves will show you that this method involves a longer time for starting up, though the energy required to attain a given speed is rather less than in the first case. In all these experiments the track was quite straight and level.

In looking at the curves which I have been showing you, no doubt you will have noticed that most of them indicate a very marked peak in the current curve at the moment when the motors are thrown over to parallel. The question may have presented itself to you whether it is not

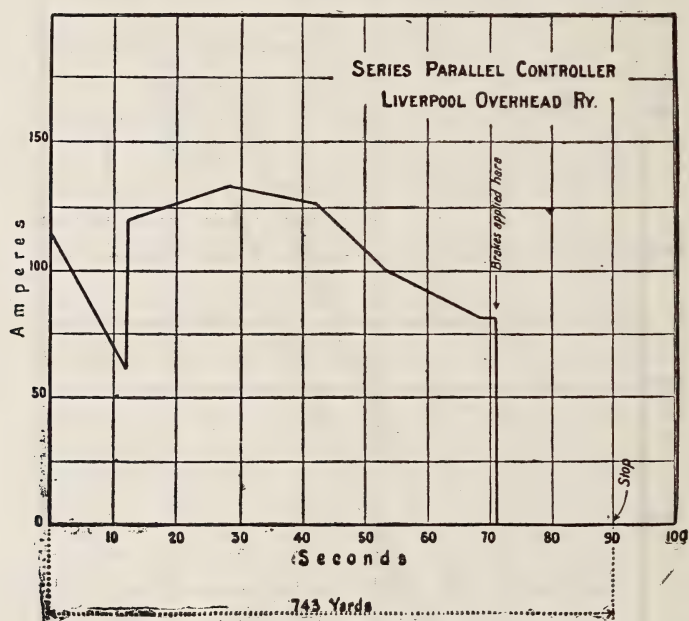


FIG. 19.

record of a test in which the controller was manipulated so as to effect a continuous start. The acceleration curve is very even and the point at which the motors are thrown over to parallel can only be detected from the current curve. The initial acceleration was about two feet per second, the motors then taking 60 amperes each. On throwing over to parallel the current from the line was increased from 120 to 200 amperes. The starting rheostat is all out in eight seconds, and the final speed is 24 miles per hour.

In the experiment of which Fig. 21 is a record, the motors were allowed to speed up for some time in series. The form of the current curve during this process is very well shown,

possible to get rid of this peak. For you are all of course aware that it is the peak in the current curves for the individual cars which are mainly responsible for the very irregular demand on the power house. It will, therefore, be worth while to consider any means of getting rid of these objectionable peaks. Let us then, for a few minutes, examine this matter.

Let us take the case of a single car weighing 10 tons, and find out how the motion is affected by taking currents of different amounts when the controller is on the parallel step. I have worked out the results on the assumption that the car is equipped with two G.E. 800 motors, and that on the series step the current per motor is 50 amperes, while on the

parallel step the current is respectively 50, 35, and 25 amperes. The results are given in the

You will notice that in each of the three cases the current per motor on the series step

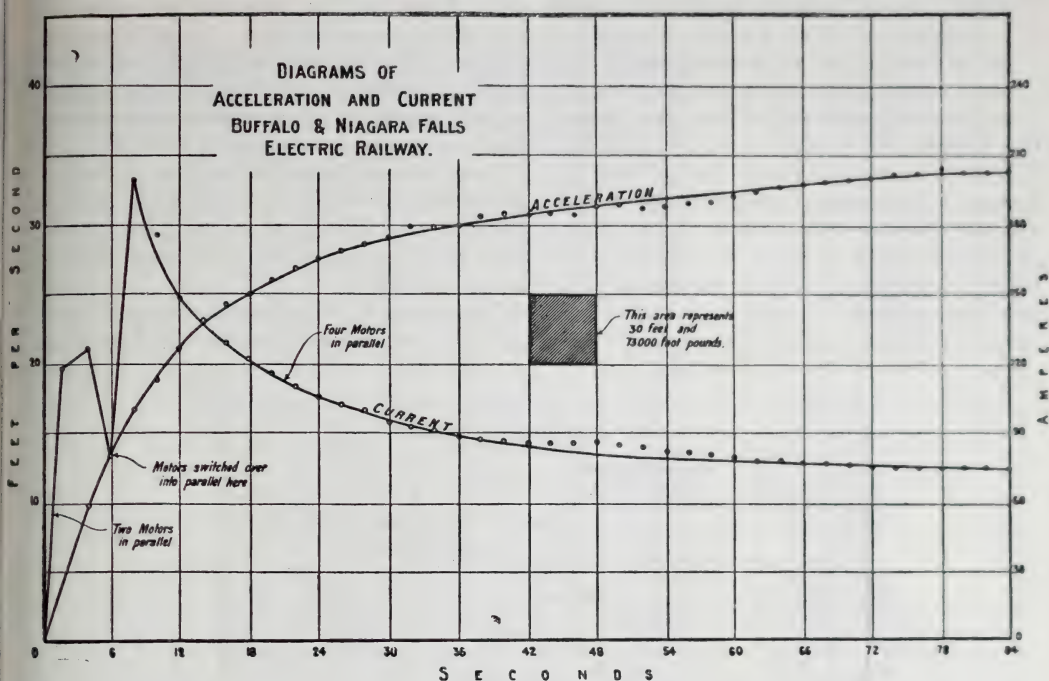


FIG. 20.

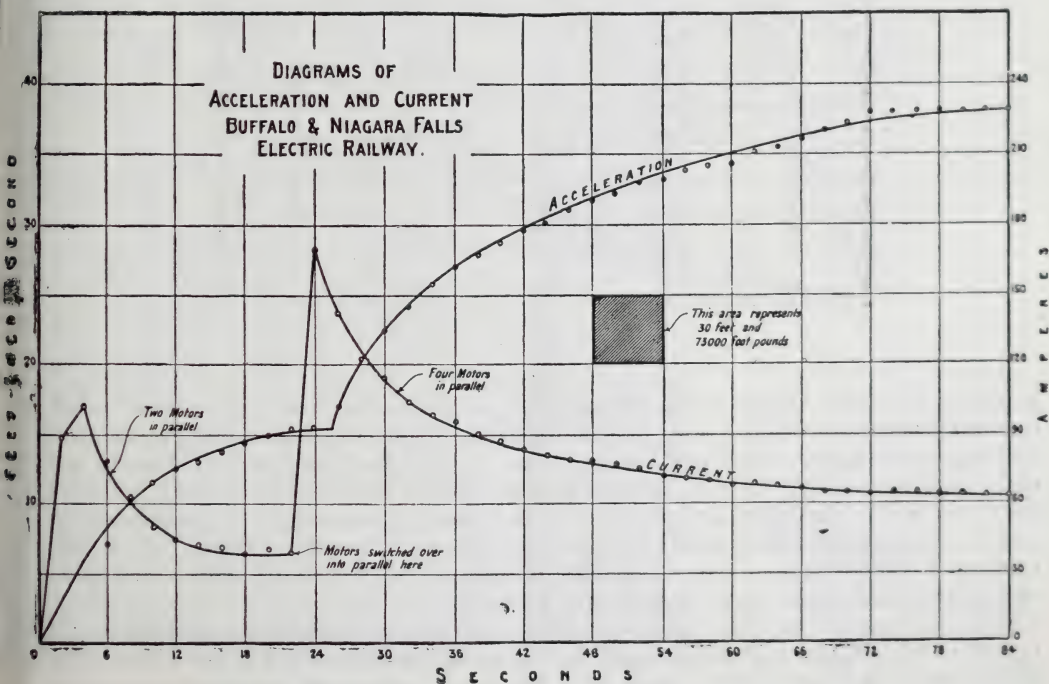


FIG. 21.

form of curves in Fig. 22. The acceleration curves have been worked out graphically from the known induction curves of the motors.

is the same, and that the difference is only on the parallel step. Of course the car makes the quickest start when the current is 50 amperes

per motor. But you see that the time required to travel 300 feet is only three seconds shorter than that required when the current per motor is 35 amperes, and is six seconds shorter than when the current is 25 amperes per motor.

The practical effect of the different currents is well shown by the curve of distances. When the distance is greater than 300 feet, the difference in time between the 50 and 25 ampere arrangement becomes constant and equal to seven seconds; that is to say, if the distance travelled is great, the gain due to taking 50 amperes per motor instead of 25 is only seven seconds. If you look at the current curves you will see how much more even is the

by using roller bearings, we may start up with the same acceleration but with a greatly reduced current, or we may start up a heavier train with the same current. On the Liverpool Overhead Railway the introduction of roller bearings enabled the engineers to add a third car without reducing the acceleration or increasing the current taken from the line.

I want, in conclusion, to bring to your notice a very important example of the application of electricity to traction, and one that has received much attention on account of the magnitude of the undertaking.

The freight service through the Belt Line tunnel on the Baltimore and Ohio Railroad, in

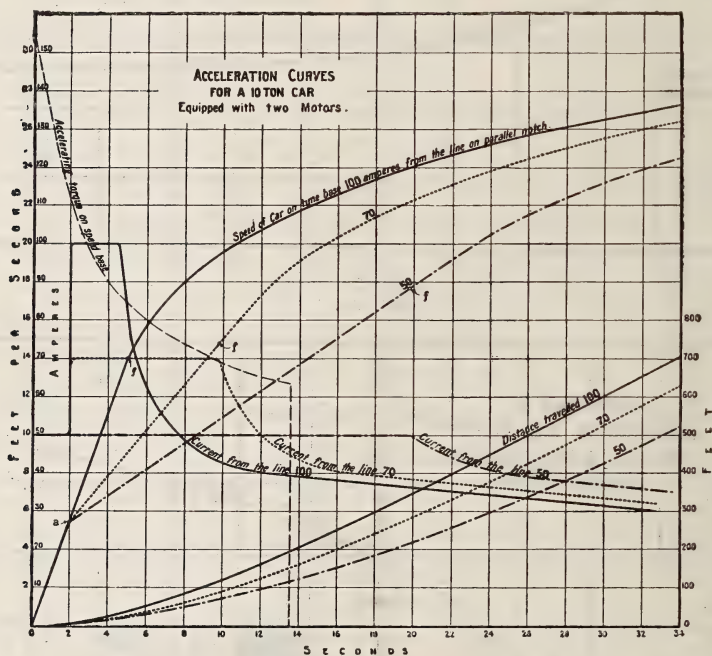


FIG. 22.

25-ampere curve than the 50. If the distance travelled is 400 feet or less, it may be worth while to gain the seven seconds at the expense of the peak in the curve; but if the distance is 800 feet or over, it would probably not be worth while. As a general rule, you will find that the current drawn from the line on the parallel step is out of all proportion to the gain in time. I need hardly remind you that the amount of current to be taken is determined simply by the resistance in series with the motors when the controller is thrown on to the parallel step.

We can effect a saving in the current required to start by reducing the frictional and other resistances opposing the motion. Thus,

Baltimore, is now carried on by means of electricity. The conditions of working are very severe. Much of the line is on a grade, and the trains to be hauled weigh between 700 and 800 tons. An account of the electrical equipment may be found in a paper by L. H. Parker in the *Street Railway Journal* for March, 1896.

The trains are hauled by locomotives, one of which is illustrated in Fig. 23. Each locomotive is made up of two trucks, a detailed view of which is given in Fig. 24. Each truck is driven by two motors, one on each axle. The armatures are built directly on the driving axles, without the use of gearing.

I do not propose to take up your time with an account of the way in which all the difficult problems connected with the design of these

alluded. I will, however, briefly indicate the application of the principles that we have been discussing to this very interesting case.

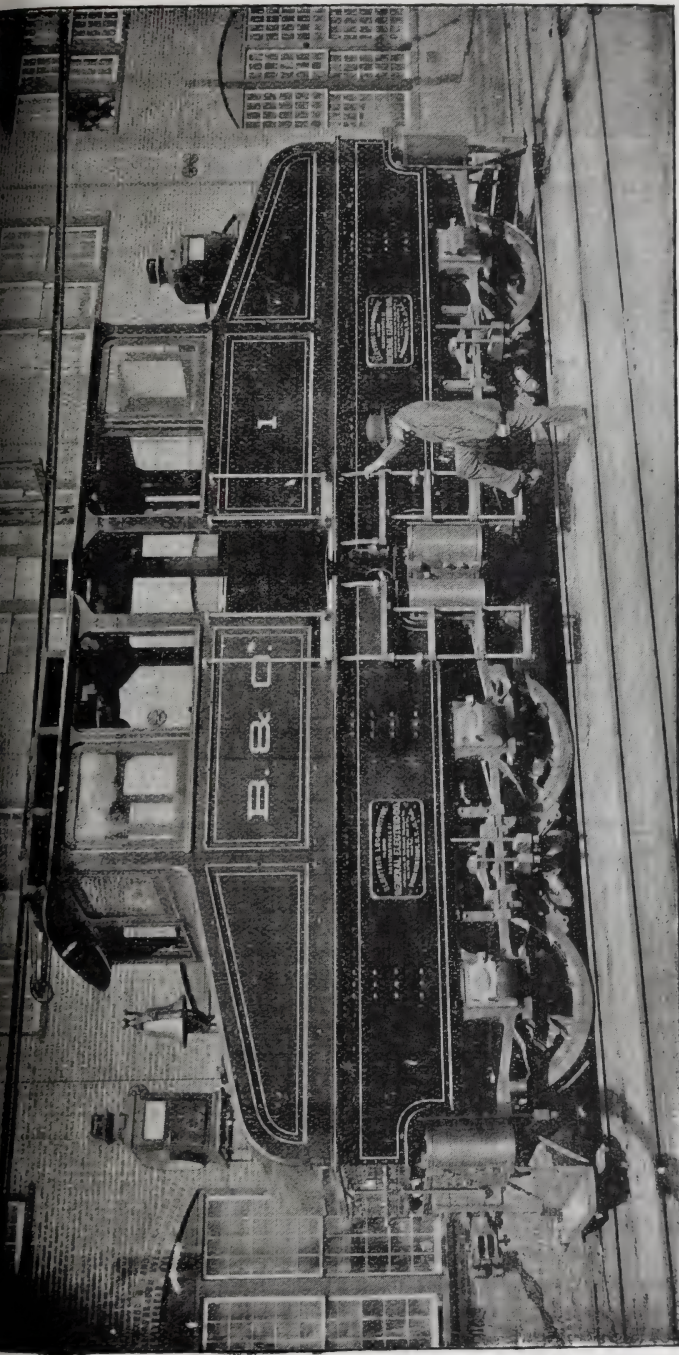


FIG. 23.

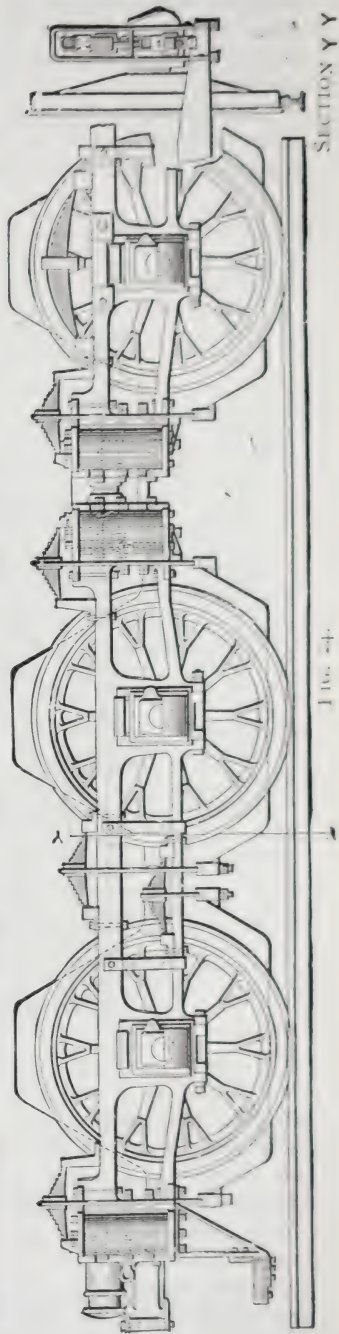


FIG. 24.

locomotives have been successfully met. Those of you who are anxious to know more can find all information in the paper to which I have

I will take the actual figures met with in practice, and assume that we have a freight train, weighing, with the locomotive, 780 tons.

This has to be started on a grade of 0·8 per cent., and hauled up the incline at 10·7 miles per hour. The frictional resistance to motion may be taken at 9 lbs. horizontal pull per ton of load. The tension of the line is 625 volts. The internal resistance of each of the four motors is 0·0209 ohms, and they are connected permanently in series.

The draw-bar pull per motor for the grade is 3,490 lbs., and for friction 1,755 lbs., making altogether 5,245 lbs. If we allow a mechanical

vice versa. But whatever values of M and d we employ, their ratio must be that given by this equation in order that the train may be hauled up the grade at the required speed. Thus, if we adopted 64 inches as the diameter of the driving wheel, we should have to make M equal to 150. The values actually used, are $M = 144$, and $d = 62$ inches.

Now, if you were to make a very simple calculation, with which I shall not now trouble you, you would find that the current required

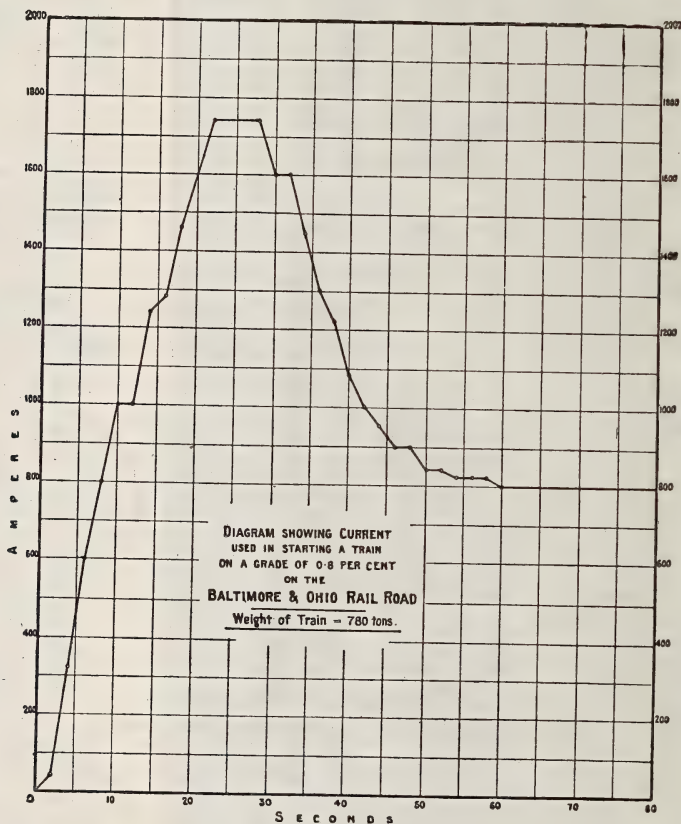


FIG. 25.

efficiency of 95 per cent., you see that each motor must be able to exert a total horizontal pull of 5,500 lbs. I have already told you that the speed when ascending the grade is to be 10·7 miles per hour, and that the velocity ratio is unity, since the motors are gearless. With these data, we can at once find the ratio of the induction factor to the diameter of the driving wheel (see note on page 860), and obtain the

equation $\frac{M}{d} = 2.33$, that is to say, if the diameter of the driving wheel is fixed, then the induction factor is given by this equation, or

to move the train against the opposing forces of friction and of the grade is almost exactly 800 amperes; but this will only enable the motors to move the train when once started; we shall have to take very much more current in order to start the train. If we knew the acceleration at which the train has to start, we can find the corresponding accelerating current by a very simple equation, given on page 156 of the book to which I have already referred you. The acceleration actually attained in practice is about 0·5 f.p.s. per second. To obtain this we require an accelerat-

ing current of 1,000 amperes, supposing the induction factor to remain the same at the start as at full speed. Now the induction factor actually increases slightly with the current, owing to the use of series winding for the magnets. I must however defer consideration of the influence of this change in the induction factor on the conditions of starting, and assume that it remains constant. Under these circumstances we should require a total current of 1,800 amperes at the moment of starting.

I can now show you, in Fig. 25, the current curve actually obtained in starting a train weighing 780 tons on the grade. You see that the total current rises gradually to very nearly 1,800 amperes; this gradual rise is necessary on account of the need of avoiding sudden shocks to the equipment. You see also that when full speed has been attained, which is in about 60 seconds from the moment of first connecting to the line, the current has fallen to 800 amperes, and the speed is 10·7 miles per hour. In examining this diagram you must bear in mind that the current must rise to 800 amperes before the train can begin to move, so that the moment at which motion commences is not where the current is nothing, but where it has this value, *i.e.*, about eight seconds from first connecting to the line.

Miscellaneous.

"FACTITIOUS AIRS."*

In 1798, just 100 years ago, Dr. Thomas Beddoes, aided, financially, by his father-in-law, Wedgwood, established in this city of Bristol the Pneumatic Institution, having for its object the treatment of consumption—and, it is believed, of other diseases—by the inhalation of various gases, then called "factitious airs."

It would appear that this mode of cure had been practised, more or less, for some years previously.

The excuses for advertising on this occasion to this institution before Section G are that we are now meeting after an interval of 100 years, in this very city of Bristol; also, and principally, that the matter was very warmly taken up by James Watt. It is probable that this warm interest was largely due to the fact of the delicate health and the consumptive tendency of James Watt's son, Gregory, who died of that disease in 1804, after having given evidence of

rare ability as an experimental philosopher, notably by his investigation into the structure of basalt, the details of which are published in the "Phil. Trans."

Through the kindness of Mr. George Tangye, of Soho, I have had the opportunity of perusing many of the letters of the Watt family, and, indeed, many of those of the Boulton and Watt partnership. In a letter of the 2nd September, 1795, James Watt, writing from Manchester to his son James, at Soho, says:—"The pneumatic medicine makes no progress at Manchester. Dr. Percival evidently does not understand the physiology of it, and Dr. Ferriar because he did not *immediately* succeed in a case of peripneumony with the H.C. (hydro-carbonate) condemns the whole. Mr. Henry says that at the infirmary they make a bungling hand of the preparation of the airs, leaving that to a parcel of ignorant boys."

In 1796 the pamphlet, of which a copy is produced, was published by James Watt. It has for the title, "Supplement to the Description of a Pneumatic Apparatus for preparing Factitious Airs, containing a Description of a Simplified Apparatus and of a Portable Apparatus," by James Watt, engineer.

It appears that Boulton and Watt manufactured these gas producers. At page 26 of the pamphlet is the price list; the cost of each set of apparatus, with accessories, varying from £10 2s. 6d. for the largest size, with an 18-inch furnace, to £7 10s. 9d. for the 13-inch furnace, and to £3 15s. for the portable apparatus.

It would appear that the original, to which the present is a supplement, is to be found in Dr. Beddoes' "Considerations on the Medical use of Factitious Airs;" and it is to be gathered that the "airs" next mentioned were to be made and used, *viz.*, oxygene air, inflammable airs from charcoal and from iron, zincic inflammable air, and fixed air from chalk; but of these, the two great "airs" relied on were oxygen and hydro-carbonate. The oxygen was to be made from manganese, preferably that from Exeter, and does not need any comment; but the so-called hydro-carbonate, and the effects produced by it, do demand some attention.

The diagram shown is reproduced from Watt's pamphlet, slightly modified so as to show the arrangements for the production of the "hydro-carbonate." A is the furnace, B the fire-tube, shown enlarged at C, and in cross-section at D, E is the arrangement for regulating the admission of water to the tube. F is a connecting pipe, leading to the gas-holder G.

To prepare hydro-carbonate air, "fill both cylinders of the fire-tube with small bits of charcoal, none of them exceeding a quarter of an inch cube, insert the water pipe into the mouth of one of the cylinders, and the end piece of the conducting pipe into the mouth of the other. . . . When the fire-tube has become perfectly red-hot, admit water by the water pipe, pretty freely, in order to expel any noxious

* Paper read before Section G (Mechanical Science) of the British Association, at the meeting at Bristol, 9th September, 1898, by Sir Frederick Bramwell, Bart., F.R.S.

matter contained in the charcoal, and suffer any air which is thus produced to escape. When this part of the operation has been continued for five or ten minutes, restrain the water and bring the airholder into its place. With a proper degree of heat and due exhibition of water a three-gallon airholder may be filled in half an hour without any steam passing into the conducting pipe, which is known by the tin parts not becoming hot."

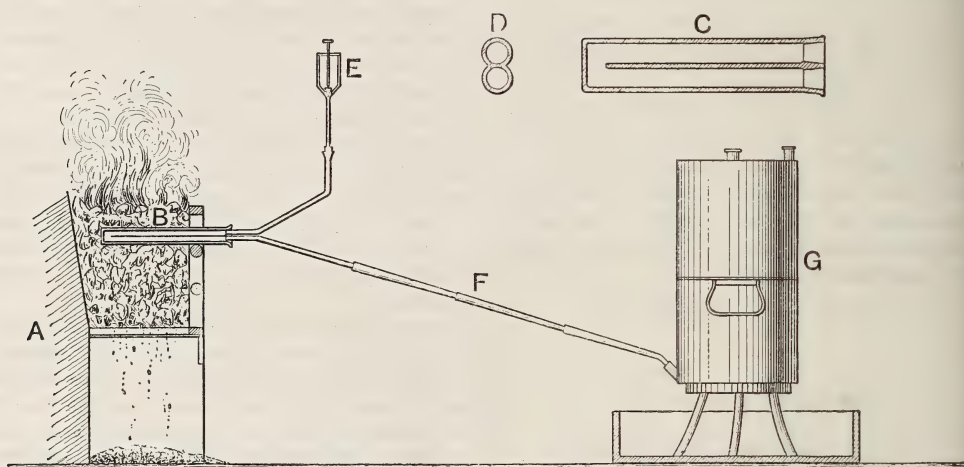
It appears that, originally, the hydro-carbonate was supposed not to be of the best quality, and not to be acting properly if the unhappy inhaler were not seized with vertigo. "A query then arose, whether it had the power of causing vertigo: a stout man inhaled a quart of it, mixed with twenty-two quarts of common air, without being in any ways affected by it, which would not have been the case if it had been prepared as usual. It would then seem that the vertigo is owing to the

proper, especially in the use of hydro-carbonate, for the patient to rest a little at every five or six inhalations, to observe whether any vertigo takes place, and even in using oxygen, an unexperienced patient should rest to avoid fatiguing the lungs, which of itself may cause some giddiness.

"The hydrocarbonate having powerful effects in causing vertigo, ought always to be administered cautiously. Where there is much debility, it may be prudent to begin with half a pint of this air, diluted with 10 to 20 pints of common air, to be increased in the subsequent doses till each dose shall cause some vertigo. How far the latter effect should be pushed must depend upon the situation of the patient and the nature of the disease."

On February the 9th, 1797, Gregory Watt, then at Penzance, wrote to his father a letter in which the following occurs:—

"We have now had five fine days in succession, a



admixture of sulphurated hydrogen, which its usual smell indicates this air to contain. If this should prove to be the fact and any part of its curative powers depends upon its producing vertigo, that effect may be secured or augmented by mixing the borings or turnings of cast iron with the charcoal, or perhaps still better by the admixture of plumbago or black lead in powder. If, upon the contrary, the vertigo does not contribute to the cure the medicine will prove more pleasant to the patient.

"In the preparation of hydro-carbonate air no water should be admitted until the fire-tube has been for some time red-hot. It is also found preferable to reduce the charcoal to small bits or to a coarse powder; and in the portable apparatus, to change the charcoal, putting in fresh at every operation, otherwise air will be produced which has not the power of causing vertigo.

"It should be recommended to patients not to hurry themselves, to inhale gently, and to retain the air a little in the lungs before they expel it. It is also

thing almost unparalleled in the annals of Penzance. They have been warm and brilliant, and have revived everybody except a poor gentleman, brother in law to John Gould. His name is Nutcombe, he is dying of a consumption, and would not consult Dr. Beddoes because the Dr. is a democrat. . . . I have procured from Dr. Luxmore the statement of a case of pneumonia which has been terminated favourably by hydro-carbonate but must, from want of room, delay this and a statement of the weather for till I write again."

Dr. Beddoes died in 1808, but before his death the pneumatic treatment was abandoned, and patients were dealt with according to ordinary medical practice.

One very interesting fact in connection with Gregory Watt and the Beddoes Institute must be mentioned, although it is probably known to many now present, and, moreover, was alluded to yesterday by the president of Section A, in his address, namely, Gregory Watt, when sent to Penzance for his health, lodged in the house of Mrs. Davy, became intimate with her son,

Humphrey, then a chemist's apprentice. Gregory Watt was much interested in young Davy, and when Dr. Beddoes started his Pneumatic Institute, Gregory recommended Davy as the superintendent. It was here that nitrous oxide was discovered, and it was from here that Davy went, in 1801, to become the assistant-lecturer at the Royal Institution.

THE ECONOMIC CONDITION OF CHILE.

Chile has a length of 2,270 miles, and a width varying from 40 to 200 miles, and Pedro de Valdivia, who led the second Spanish expedition against the country, likened it to the blade of the sword, because of its great length and narrowness. Its area is 293,970 square miles, and, according to the census of 1895, the population was stated at 2,712,145 or 9.2 inhabitants per square mile. The population now probably exceeds 3,200,000, and of this number 1,500,000 are engaged in agriculture, producing annually about 28,500,000 bushels of wheat, and 9,000,000 bushels of other cereals, besides vegetables, fruits, &c. It is stated upon good authority that more than 500,000 head of cattle, and 2,000,000 sheep, goats, &c., are raised in the country each year. The mineral products, in the way of copper, silver, gold, coal, manganese, &c., are extensive. Chile's nitrate fields cover an area of about 220,356 acres, estimated to contain 2,316,000,000 metric quintals (228,000,000 tons) of the nitrate of commerce. The total product from these fields in 1896 is stated, in a recent report by the Bureau of American Republics, to have been 1,092,000 tons. An idea of the industrial development of Chile may be gained from the fact that in 1895, in the Department of Valparaiso, with a population of less than 200,000, there were 417 industrial establishments which during the year employed 12,616 operatives, with 162 steam-engines, having a total of 1,766 horse-power. Among these establishments were gas works, breweries, sugar refineries, carriage and waggon works, sawmills, mineral and aerated water factories, &c. Tanneries form a flourishing branch of the manufacturing industry. Chile was the first country in South America to construct railroads. At the beginning of 1896, the total length of railways in the Republic was 2,080 miles, and of these 838 miles were owned and worked by the State. Private corporations owned and operated 1,242 miles represented by 15 different lines. The leading line is the Grand Central, belonging to the State, which is composed of three divisions—from Valparaiso to Santiago, and thence to Melipilla; from Santiago to Talca, from San Fernando to Alcones, and from Pelequen to Peumo; from Talca to Talcahuano, San Rosendo to Traiguén, Santa Fé to Los Angeles, and Robleria, to Victoria a total of 766 miles. Work on the Transandine Railway is now being vigorously proceeded with. There are 25,000 miles of public roads and 2,875 miles of waterway in the country. At the end of 1895 the length of the State telegraph

lines was 6,965 miles, with 8,330 miles of wire. Chile's merchant navy consisted in 1896 of 188 vessels, with a tonnage of 105,642 tons. Forty-two of these vessels were steamers. English, German, and French lines of steamships ply regularly between the coasts of Chile and Europe through the Straits of Magellan, and constant and direct communication is maintained by Chilean and foreign steamship lines along the coast as far as Panama, there connecting with steamers for the Atlantic, Pacific, and Gulf ports of the United States and for Europe. Chile imports the bulk of the manufactured goods she consumes, but the Government offers inducements for the establishment of new industries, and is anxious to promote manufactures. The Government recently appropriated £100,000 to foster iron and steel enterprises, it having been demonstrated that a high grade of iron ore exists in abundance in the country. In 1896, the latest year for which the figures are available, the value of the imports into Chile amounted to £15,434,000, and the exports to £15,491,000.

Correspondence.

DETERIORATION OF PAPER.

In Appendix II. (Précis of Correspondence) to the Report of the Committee of the Society of Arts on the Deterioration of Paper (p. 42), there is the following abstract of a letter of Mr. J. W. North, A.R.A., Chairman of the O.W. Paper and Arts Company, Ltd.:—"Points out the vital importance of this subject to artists, and sends samples of papers absolutely guaranteed by the O.W. Paper and Arts Company, Ltd. This paper is also suitable for books." Mr. North considers this abstract is misleading, and writes, "The inception of the O.W. Paper and Arts Co. dates back more than 25 years (see 'Life and Letters of F. Walker, A.R.A.' Macmillan and Co.), the basis being the necessity for securing the good quality of paper by means of a guarantee to be given by a body whose interest in the absolutely pure and reliable character of paper would be unquestionable. Such a body exists in the Royal Society of Painters in Water Colours, as representing workers in water colours, who have more to lose by the inferior character of papers than any other individuals. The R.W. Society, who obtain the highest scientific aid, submit the O.W. paper intended to be painted upon to careful examination and analysis, and having been satisfied by the report of their analyst, then, as a guarantee of purity, impress their stamp (over which they have complete control) on O.W. water-marked papers intended for printing upon."

"The guarantee is not, as suggested, simply that of the O.W. Paper and Arts Co., but of an entire independent society.

"The guarantee of the O.W. Paper and Arts Co.

extends to this, that all other O.W. Co. waterproofed papers are guaranteed as being made of the same material as those stamped by the Royal Society of Painters in Water Colours. It will be seen, therefore, that not only does the O.W. Paper and Arts Co. supply a pure and reliable linen rag paper, but that this paper is guaranteed by a competent and independent society; and that the admirable suggestion as to a guaranteed pure rag paper contained in Mr. James G. Flowerdew Lowson's letter on page 40 of the report, has been anticipated."

Notes on Books.

THE ANGORA GOAT. By S. C. Cronwright Schreiner. London: Longmans, Green, and Co. 1898.

This book, which is published under the auspices of the South African Angora Goat Breeders' Association, gives a full and interesting account of the introduction of the animal into South Africa. The story is rather a curious one. As far back as 1725 an effort was made to establish Cashmere goats in the Cape Colony, but this and some later attempts were not successful. In 1838 an attempt to introduce the long-haired Angora goat into the Cape was made by Colonel Henderson, who imported, at considerable expense, twelve rams and one ewe. The twelve rams, however, appear to have been castrated before they left Turkey, and the experiment would have failed, but that fortunately a ram kid was born to the ewe, and by crossing this ram with Boer goats, a valuable breed of animals was produced. Later on larger importations of the Angora were made, and the result was to breed up a large number of wool-bearing goats, and to establish what is now a very important industry. A short paper by the same author on the "Ostrich" is also included in the work.

A POCKET DICTIONARY OF HYGIENE. By C. T. Kingzett and D. Homfray. London: Baillière, Tindall, and Cox. 1898.

The object of this little book is to provide in a condensed and convenient form, information likely to be useful to medical and sanitary officers in connection with their work. The information is of a very varied character. Such headings as "Water," "Drains," "Duties of sanitary inspectors," "Sanitary statutes," and "Disinfection" are treated at some length, while summarised information is provided about diseases, and about appliances and materials likely to be employed in connection with sanitary work. It may be remarked that rather undue stress is laid on the merits of one particular and well-known disinfectant. It looks as if one of the main objects of the book were to bring this material into notice,

General Notes.

COAL IN KENT.—At the recent meeting of the British Association at Bristol, Mr. R. Ethridge read a paper (before the Geological Section) on the "Relation and Extension of the Franco-Belgian Coalfield to those of Kent and Somerset." He showed by frequent references to diagrams that the coalfields of Belgium and North France occupied an extended and sinuous line from east to west, ranging through about 150 miles in that line. There was little doubt, he thought, that the Belgian coalfields extended westwards to Valenciennes, Condé, and Bethune, and on to Calais, thence under the Straits of Dover to the now determined coalfields of south-eastern Kent. Borings were being made at Pluckley, west of Brabourne, and Penshurst, the latter being 25 miles west of Dover, and some 1,700 feet deep. The Brabourne trial had passed through 1,875 feet of sedimentary rocks ranging from the Gault to the Lower Lias inclusive, and the bore-hole had passed into the red conglomerate of probably old red sandstone, but in all probability the depth would be increased. The Dover bore-hole reached the depth of 2,225 feet, having proved eight seams of coal, the lowest being 4 feet thick. This was thicker than any known seam in the Belgian coalfield.

SOUTH KENSINGTON MUSEUM.—Through the generosity of Colonel F. R. Waldo Sibthorp, the South Kensington Museum has lately become possessed of a large collection of silversmiths' work, chiefly German, ranging in date from the 16th century to the present time. These specimens are very varied in form, and include tankards, flagons, beakers, and salvers, decorated in *repoussé*, and by engraving with flowers, scrollwork, and figure subjects; there is also a considerable collection of spoons. Among the pieces of historical interest is a standing cup and cover surmounted by a bust of Gustavus Adolphus, King of Sweden, and with an inscription in his honour. There are a number of specimens of the work of English silversmiths, the most important being two communion cups of Queen Elizabeth's reign, one of which retains its paten-cover. The series of English spoons covers a considerable period of time; they are interesting on account of the Hallmarks, the decorations of the handles, and the shapes of the bowls. The handles of some terminate in figures of Apostles, others are seal-topped, whilst others are of the plain "sleppe endy" form. A set of tea-spoons in the shape of shells with dolphin handles formerly belonged to Lord Nelson. Colonel Sibthorp has included in his gift a small collection of snuff-boxes of the last century, two of which are specially deserving of notice; the first is of tinted gold set with diamonds and other jewels, the second is of enamel, and has inside the lid a portrait of Peter the Great, painted by Crodowiczky.

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FRIDAY, OCTOBER 7, 1898.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****EXAMINATIONS, 1899.**

The dates fixed for the Society's Examinations in 1899 are Monday, March 13th, Tuesday, 14th, Wednesday, 15th, and Thursday, 16th.

The Programme of Examinations is now ready. Copies of the Programme, with full details, and an Appendix containing last year's questions and reports by the Examiners, can be had, price 3d., post free, on application to the Secretary, Sir Henry Trueman Wood, Society of Arts, Adelphi, W.C.

Proceedings of the Society.**CANTOR LECTURES.****ELECTRIC TRACTION.**

BY PROF. CHARLES A. CARUS-WILSON.
M.A., M.Inst.E.E.

Lecture IV.—Delivered May 23, 1898.

At the commencement of this course of lectures I reminded you that it would be impossible in so short a time as we have at our disposal to cover any but a small part of the wide field of electric traction, so I propose to-night to take up one of the many questions that might engage our attention, and to confine my remarks entirely to the discussion of a problem that has already presented itself for solution to electrical engineers.

A good illustration of this problem is to be found in the new Central London Railway. Heavy trains have to be started from rest and moved through comparatively short distances in correspondingly short times. Full speed is rarely, if ever, reached. The whole process consists of getting up speed and then putting on the brakes.

In the case of the particular railway that I have quoted, the trains weigh about 150 tons,

and have to cover an average distance, from station to station, of rather less than half a mile, in a time, including stops at the station, of about 115 seconds.

You will at once see that this is an entirely new problem. The old methods by which we designed a motor to run at a uniform speed will be of no service to us here. The question turns entirely upon the action of the motor during the period of acceleration. Since the speed is continually varying, it will be of no use to define the horse-power of the motors, as may be done when the speed is uniform. We have to design an equipment that will start the train from rest, and carry it through the given distance in the given time. I propose then to direct your attention this evening to some principles which should guide us in designing motors to fulfil these peculiar conditions.

And first let me state briefly the problem and the data that we have given to us. We have W , the weight of the train in tons; this has to be moved through a distance of D feet in t seconds from start to stop. We know the resistance to motion, including track and gear friction; we have the tension of the line in volts, and the internal drop in the motors at full speed.

I should like to make it clear to you that we have not simply got to design the motor or motors—that is only one part of our problem; we have to design a complete equipment. Let me explain what I mean by that term. I mean that the subject of our consideration is the complete apparatus upon which the motion of the train depends. You will see at once that the motion of the train depends quite as much on the diameter of the driving-wheel, for instance, as upon the speed of the motor. It also depends equally upon the ratio of the gearing. I hope that before the end of the lecture I may have shown you that these three quantities are all possible variants, so to speak, in our problem, and that successful design depends upon the proper choice of all three.

I prefer then to speak of the design of an equipment, including in that expression (1) the motor itself, (2) the driving-wheel, and (3) the gearing. We are, or should be, at liberty to adjust all these in order to get the best results. Unfortunately it is very often the case that certain restrictions are imposed upon the designer by those who are in ignorance of the real elements of successful design, and who think that the question of the design of the motors is quite the last thing to be considered.

For instance, there may be some latent prejudice against the use of gearing, and this

may be prescribed in the specification; this may so curtail the powers of the designer that motors may have to be installed resulting in a permanent loss of 10 or even 20 per cent. of energy. Again, in the case of tunnels, the head-room may be so restricted that it may be impossible to use driving wheels of the right diameter. When the engineers were deciding upon the size of the tunnels, they probably never thought for a moment that the economy of running might depend upon the available head-room.

In the preceding lectures I have used d to denote the diameter of the driving wheels, v the velocity ratio, and M the induction factor of the motor. I shall adhere to these symbols throughout. We may now consider ourselves at liberty to adopt any value for any of these quantities, our aim being to comply with the specification as to time and distance in the best possible manner.

And here I must answer a question that will occur to you when I use the expression, "the best possible manner." What do I mean by this? What is to be our standard of excellence of design? In designing a motor for ordinary work we look to the efficiency, and specify that the motor shall run with a given load at such an efficiency. In the problem before us such a statement would be meaningless, since the motors rarely, if ever, attain their full speed, and for most of the time are accelerating and, consequently, running with an efficiency that may be anything down to zero at the moment when motion commences. Hence to specify that the motors must give such a horse-power at such a speed with such an efficiency, though it may secure that efficiency at that speed, leaves the much larger question of the economy of the whole performance entirely vague.

The best way to state the efficiency question in such a case as this is to say that the whole performance, from start to stop, requires so much energy. This may be conveniently put in the form of so many foot-pounds or watt-hours of energy per ton-mile. Of course this leaves out of account altogether the efficiency at any particular speed, but it states the really important thing for us to know. It is of no use specifying a high efficiency at a certain speed, when the economy of running may be anything from 80 to 160 watt-hours per ton-mile.

But there is another aspect of the question which you must not overlook, which is that to specify beforehand the horse-power and speed of the motors, as in the case of a line where

uniform speed is the rule and not the exception, is to impose most serious limitations on the designer, and to oblige him to adopt a design that may be 20 or 30 per cent. less economical than would be possible without such restrictions. In discussing our problem then, I shall assume that we are quite free from all requirements as to horse-power and speed, and that we are at liberty to select those values of M , v , and d , that give us the best results when expressed in terms of watt-hours per ton-mile.

Let us now take each of these three quantities and see how far they influence the final speed of the train or car when uniform speed has been attained. If we denote by s the speed of the car in feet per second, we see that if M and v are constant, s will increase with d , *i.e.*, the speed will increase with the diameter of the driving wheel. So that if the whole of the rest of the equipment is unaltered, an increase in the diameter of the driving wheel will mean an increase in the final speed. On the other hand, it is obvious that if d is kept constant, the final speed will diminish as M is increased, and will also diminish as v is increased. Hence we can say that s varies as

$\frac{d}{M v}$. Now if the tension of the line is constant

and the drop at full speed given, *i.e.*, if we are at liberty to adjust R , the resistance of the motor, so that whatever the current at full speed may be, the drop is the same, then the induced volts, which we may denote by e , is also constant. Thus our equation for the speed

may be written, s varies as $\frac{d e}{M v}$. To make this

equation of use for actual calculation we must select the proper numerical constant, and we obtain finally—

$$s = 0.262 \frac{d e}{M v} \dots\dots\dots (1).$$

This equation tells us exactly how the final uniform speed is affected by any alteration in any of the quantities M , v , or d .

Now how do variations in these same quantities affect the rate at which uniform speed is attained? That is to say, if we alter d , for instance, what will be the effect on the acceleration? You will see at once that an increase in the diameter of the driving wheel will diminish the acceleration, other things remaining the same. Similarly, an increase in M will increase the acceleration; so will also an increase in v , so that if W the weight of the car is given, and C_a the current available for acceleration, we know that a the acceleration

varies as $\frac{Mv}{d} \frac{Ca}{W}$. If you want to use this relation in your calculations you must select the right numerical constant. Since a is expressed in f.p.s. per second, the constant will be 0.04, and we have the equation—

$$a = 0.04 \frac{Mv}{d} \frac{Ca}{W} \dots\dots (2).$$

You are now in possession of complete information as to the effect upon the curve of acceleration of any change in the values of M , v , or d . Imagine to yourself an equipment of any kind you please. With a given accelerating current your car will start with an accelera-

tion will be increased from 1.5 to 2.0 f.p.s. per second, but the final speed will be reduced from 30 to 22.5 feet per second. The acceleration curve is thus completely altered, and you will notice that precisely the same change could have been effected by a proportional increase

in either M or v , since the ratio $\frac{Mv}{d}$ enters into both our equations.

I have drawn the acceleration curve with the 30-inch wheel until the area enclosed is the same as it was with the 40-inch wheel, *i.e.*, until the car has covered a distance of 200 yards, and you see that the time of covering this distance has been increased from 30 to 32

TIME CURVES
FOR DIFFERENT DISTANCES
AND WHEEL DIAMETERS.

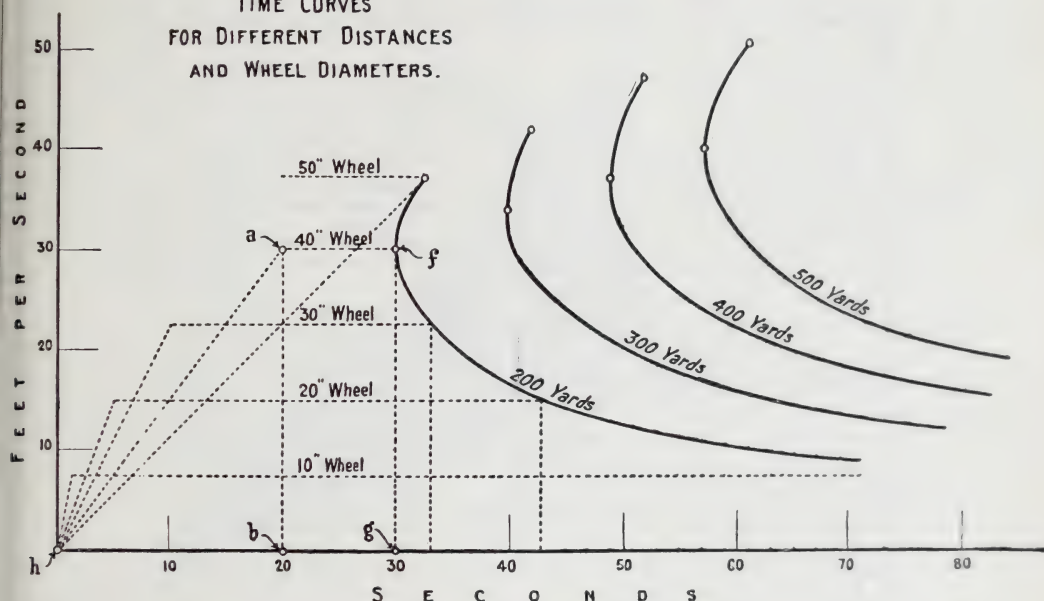


FIG. 26.

tion given by equation (2), and will speed up with that acceleration practically until full speed is reached, this speed being given by equation (1). Suppose that your car is so equipped that it speeds up with an acceleration of 1.5 f.p.s. per second on a 40-inch wheel, the final speed being 30 feet per second. The acceleration curve with this equipment is shown in Fig. 26, that is now on the screen before you. We may suppose the curve terminates where the enclosed area equals 200 yards, *i.e.*, the car will then have covered a distance of 200 yards.

Now what will be the effect of altering the diameter of the driving wheel, say to 30 inches, without making any other change? From our equations we see at once that the acceleration

seconds. A 20-inch wheel would take 43 seconds to cover the same distance, and a 10-inch wheel would take nearly 100 seconds.

The points on the acceleration curves giving the time required to cover equal distances lie on a curve that we shall call a Time Curve. You see from the figure that this curve is convex to the speed axis, that is to say, there is a certain value for the diameter of the driving wheel that covers the distance in a shorter time than any other. In this case the best diameter is 40 inches, for you see that a 50-inch wheel again takes a longer time. Hence with this particular equipment, a 40-inch wheel will cover 200 yards in a shorter time than any other wheel. You must however observe that

for any other distance 40 inches will not be the best diameter; thus for 400 yards the best diameter is 50 inches.

If you examine the acceleration curve for the 40-inch wheel more closely, you will see that of the whole 200 yards, one-half is covered during the process of acceleration, and one-half at full speed. Now this gives us a very important result, namely, that to cover a given distance in the shortest time, our equipment must be so designed that one-half the distance is covered when running at full speed, the time of full-speed running being necessarily one-third of the whole time. It follows from this that when we have to cover a given distance in a given

Without going further into this question now, let us assume that we can stop the car in ten seconds in a distance of 100 feet. This leaves us with 500 feet to be covered in 30 seconds. To begin with, we know what the final speed must be, for we have to cover 250 feet in ten seconds, *i.e.*, full speed is 25 feet per second. Since the tension of the line is 500 volts, and the drop at full speed is nine volts, we get e , the induced volts, equal to 491. Hence, from

equation (1) we have $\frac{M v}{d} = 5 \cdot 15$. Suppose now that $v = 4 \cdot 78$, and that $d = 33$ inches, we get then $M = 35 \cdot 5$. With these values of M , v , and d , the current at full speed must be

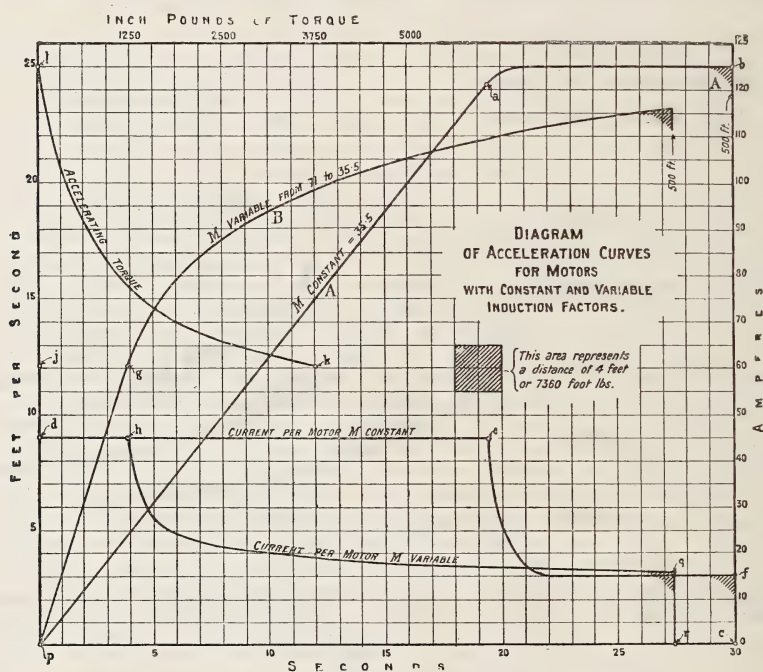


FIG. 27.

time, we shall do so with least accelerating current when half the given distance is covered at full speed in one-third the given time.

To make this clearer, let us take a definite case. Suppose that we have to design an equipment that will start a car weighing ten tons and carry it through 600 feet in 40 seconds. Two motors are to be used connected in parallel throughout; the tension of the line is 500 volts. The drop at full speed is to be nine volts. The frictional and other forces retarding the motion amount to 3,580 inch-pounds of torque on each axle.

First of all we have to consider the period during which the brakes are being put on.

15 amperes per motor, and the resistance of each motor 0.6 ohm.

So far we know that if we construct an equipment with these values of M , v , and d , the car will move at the required speed against the given resistances to motion, and one-half the given distance will be covered in one-third the given time. In order to get up 25 feet per second in 20 seconds, the acceleration must be 1.25 f.p.s. per second. Inserting this in equation (2), remembering that W per motor is five tons, we obtain the accelerating current and find it to be 30 amperes, so that the total current at starting will be 45 amperes.

The acceleration curve obtained with this

equipment, up to the point where the brakes are put on, is shown in Fig. 27. The acceleration is constant at 1.25 f.p.s. per second for 20 seconds, and during this period 250 feet are covered. The rest of the distance is covered at full speed at 17 miles an hour.

In the same diagram you see the current curve. The maximum current, 45 amperes, is constant for 20 seconds: during this period the starting rheostat is being gradually taken out; when it is all out the current rapidly diminishes to 15 amperes per motor. The area of this curve gives us the total work done, and in this case amounts to 387,000 foot-pounds of energy.

curve that you have already seen in Fig. 27. You know that the area of this curve represents the expenditure of energy. Hence it should be the aim of the designer to reduce this area as much as possible.

Let us begin by analysing this area, and separating the different items of energy expenditure. This I may do by drawing lines dividing the area into three parts, each representing an entirely distinct item of expenditure. I have done this by dividing the vertical ordinates of the current curve into three parts, each representing that portion of the whole current that is expended in the three different ways of

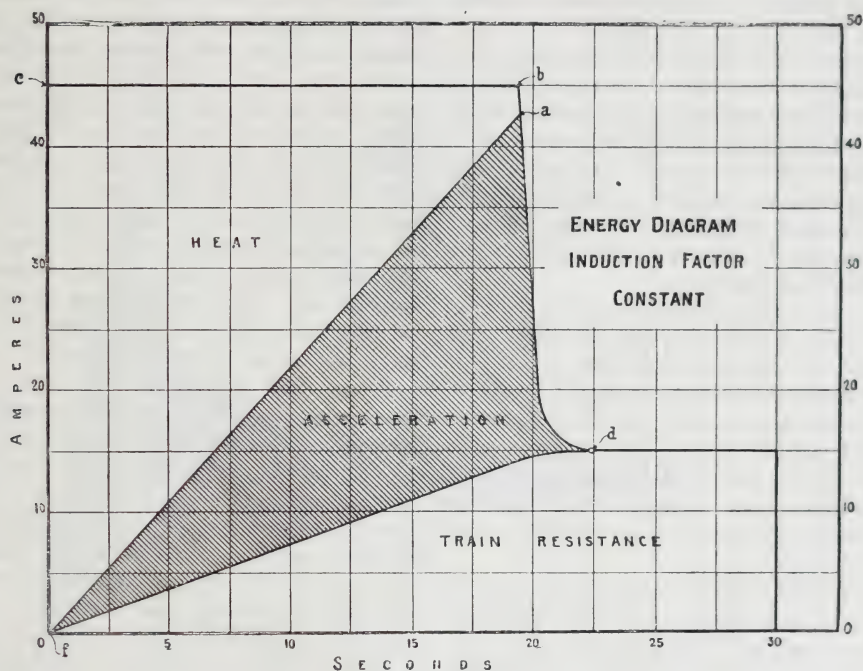


FIG. 28.

We have thus designed an equipment that will cover the given distance in the given time, but the question now arises, "Does this design comply with the specification in the most economical manner?" The answer to this is that any alteration in the values of M , v , or d , that we have selected will require a larger accelerating current to cover the distance in the given time, so long as the value of M remains constant throughout, *i.e.*, so long as we adopt what is practically a shunt-wound motor. If, however, we are at liberty to vary the induction factor by using series-winding, we may be able to effect a greater economy. Let us then see what this series-winding can do for us.

In Fig. 28 I have reproduced the current

heat, acceleration, and train resistance. You see that at the moment of starting the whole of the energy is being expended in the form of heat. As the speed increases less is expended thus, and some in overcoming train resistance and some in accelerating. When full speed is reached the only expenditure is for train resistance.

You will notice that the rate of energy expenditure in overcoming train resistance is not uniform, as it is sometimes supposed to be. This should be obvious when you remember that it depends upon the speed, the resistance to be overcome remaining constant, so that at the moment of starting it is nothing. I mention this because some recent calculations on moto

control and energy expenditure have been based upon the assumption that the rate of energy expenditure for train resistance is uniform, so that the whole energy thus expended simply depends on the time, whereas it really depends upon the distance.

When the distance to be covered is fixed, the only way of reducing this item of expenditure is to reduce the resistance to motion. This we may do by using roller bearings or other similar devices. When however we have reduced it to the lowest limit the expenditure under this head may be found by multiplying the resistance to motion, expressed in terms of so many pounds of horizontal effort, by the distance that has to be covered.

We now come to the second item of expenditure, namely, acceleration. This represents the kinetic energy stored up in the moving train, and depends upon the weight to be moved and the square of the final speed. The only way of effecting a saving under this head will be to reduce the final speed, and since the expenditure varies as the square of the speed, it will be well worth doing this.

Now I have already shown you that the best speed is that which covers half the distance in one-third the time, and that if we run with a smaller final speed than this we shall have to increase the accelerating current. Since the heat expenditure varies as the square of this current, it will not be worth while adopting a lower final speed. It appears then that the saving of energy must be made, if at all, under the head of heat.

I want you to notice that the heat energy is represented very nearly by a triangle, drawn by joining the point *f* to the point *b*. The little distance *a b* is, in fact, the rate of expenditure of energy due to the initial current passing through the resistance of the motor only. As the initial current rapidly diminishes, this state of affairs lasts for a very short time. I shall therefore assume that the heat loss is found by joining *f* to *b*, and is given by the area of the triangle *c b f*. Now how can we reduce the area of this triangle? One way is by using the series-parallel controller. Let me explain.

The current curve that you are now looking at represents the current for one motor. If we have two motors and connect them in series at starting, and maintain the same current per motor as before, we shall have 45 amperes from the line instead of 90, and this will last until the rheostat is all out on the series step, *i.e.*, for ten seconds, hence we shall cut a large

rectangle out of the heat triangle like that shown in Fig. 33. If I have made this clear, you will see that the series-parallel controller enables us to halve the heat loss when two motors are used. This is a very important conclusion, since it shows us wherein lies the great advantage of this method of control. Whatever arrangement we adopt, however we design our equipment, if we use shunt or series-wound motors, the series-parallel controller halves the heat loss.

If four motors are used, the question may arise as to whether it is worth while connecting them four in series at the start. Under these circumstances, the heat loss is not again halved. Suppose the heat loss with parallel connection to be 100, then by arranging the motors two in series at starting we reduce the heat loss to 50. By arranging them four in series at starting the heat loss becomes 37.5. This is on the assumption that we neglect the resistance of the motors themselves, and makes the saving rather larger than it actually is. It is, in general, not worth while to connect four in series, since the connections become very complicated. This arrangement might however be justified if it was considered necessary to be able to run at very slow speeds.

I want now to direct your attention to another very important method of reducing the heat loss. To make myself clear I must begin by asking you to imagine that you are in possession of a mechanical contrivance that at present exists only in the brain of the ardent inventor, namely, a contrivance by which you can vary at will the velocity ratio. Imagine that your car is equipped with such a contrivance, and that by simply moving a handle you can increase or diminish *v* without making any other alteration in your equipment. Let us see what this would enable you to do.

At the moment of starting you would make *v* as large as possible. Suppose, for instance, that you could double *v*, you would then get twice as great an acceleration as before with the same current. Now if you kept *v* at this value, your car would speed up to half the proper speed and you would not cover the required distance in the given time. If however you kept on reducing the value of *v* as the car increased in speed, you could bring up the speed to the same final speed as before, namely, with $v = 4.78$. There would, however, be this great difference from the case when *v* was constant, that the high initial current would last only so long as the initial value of *v* was maintained, in other words, the starting

rheostat would be in circuit for a very much shorter period.

You see then what a valuable contrivance this would be, it would enable us to get rid of the heat loss entirely, theoretically, and even with the practical limits that we may suppose to exist, we could reduce the heat loss very greatly. I may point out in passing that the limit would be determined not by the practical difficulty of constructing a contrivance with an infinite velocity ratio, but by the initial acceleration at which slipping of the driving wheels would take place.

Now I do not wish to discourage any inventor amongst my audience to-night, when I say

of M at the moment of starting, and make it gradually get less as the car speeds up, we can do all that we could do with a variable velocity ratio. Now series-winding does this for us automatically. By winding the magnets in series with the armature, so that the whole current passes through both, we can reduce the time during which the starting rheostat is in circuit as much as we please.

Suppose, for instance, that we design our motor so that when 45 amperes are passing through the magnets the induction factor is twice what it is when 15 amperes are passing. We shall get acceleration and current curves as

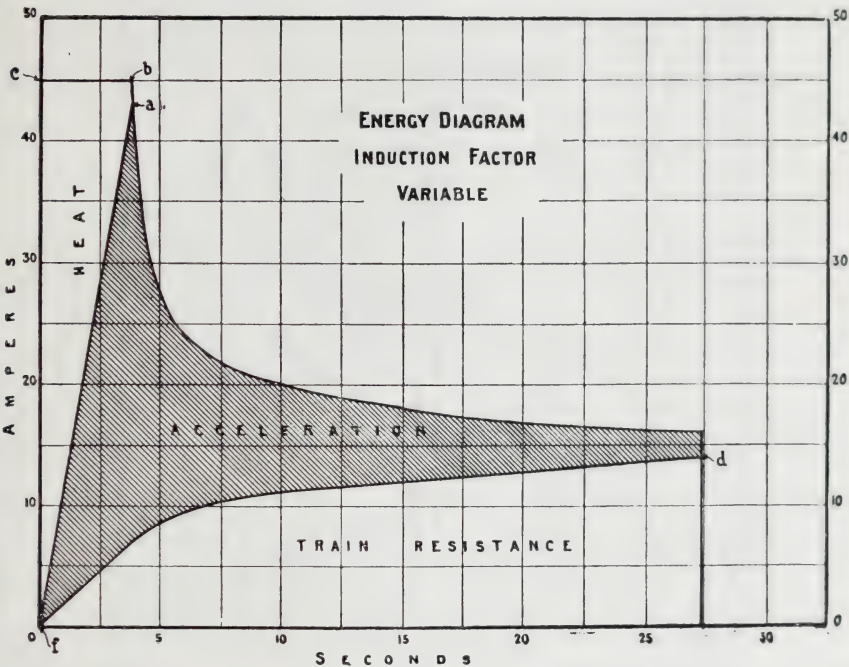


FIG. 29.

that we have ready to hand a contrivance that does all that I have been imagining, and even more, as the contrivance that I now speak of acts automatically. I refer to what is known as series-winding.

You have already seen that the three quantities, M , v , and d , are so related that whatever change we make by varying any one of them we can effect precisely the same change by varying one of the others. For instance, all that I have just said about varying the value of v applies with equal truth, though with insuperable practical difficulties, to varying the diameter of the driving wheel.

It follows that if we can increase the value

shown you in Fig. 27. The point g now marks the moment at which the starting rheostat is all out. The high initial current is thus passing for 4 seconds instead of for 20, and the corresponding saving in the heat loss is shown by a comparison of the areas of the current curves.

In Fig. 29 I have drawn the new current curve, and divided the area so that you can at once see by comparison with Fig. 28 where the saving has been effected. In each case 500 feet has been covered. You see that the saving is almost entirely on the heat loss. The actual values are given in the following Table.

	Induction Factor.	
	Constant.	Variable.
For acceleration	Foot-pounds. 109×10^3	Foot-pounds. 88.7×10^3
For train resistance	109×10^3	109.0×10^3
For C ² R loss	169×10^3	32.2×10^3
Total for half car	387×10^3	229.9×10^3

You see, then, that by making use of the principle of series-winding we have been able to reduce the heat loss, and in consequence

on the curve, which has then to pass through the three points thus shown. The point *b* is determined by the final speed that has to be attained, and the point *f* should be taken as high up as possible in order to get as large an initial acceleration as possible.

It should be clear to you from the figure that the point *f* is not the highest possible value of *M*. This would be obtained by drawing a straight line through *a* and *b* to cut the vertical through *f* in *c*. The value of *M* thus obtained, *M* = 106, is the greatest possible value consistent with having *M* = 35.5 for 15 amperes.

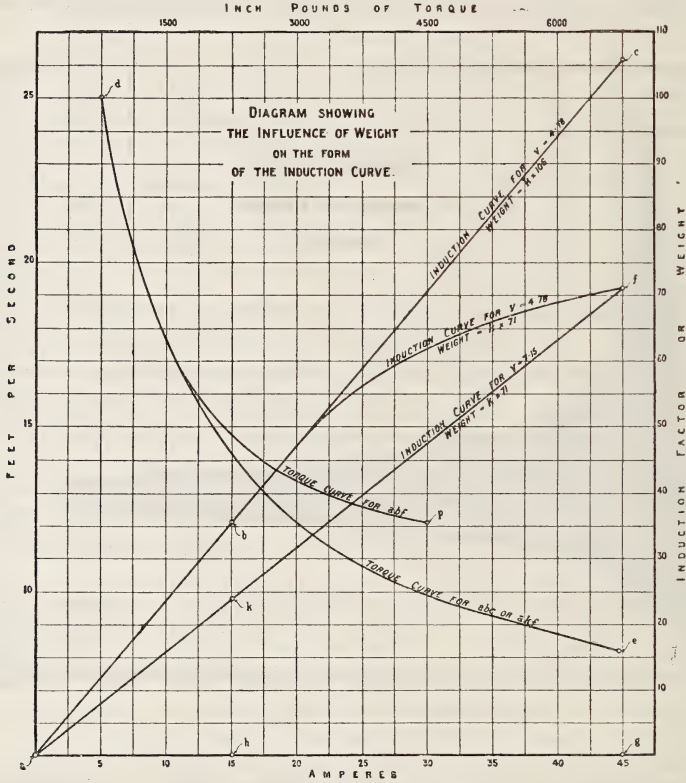


FIG. 30.

to carry the car through the required distance in the given time for 40 per cent. less energy than with motors of constant induction factor. I wish now to direct your attention for a few minutes to the induction curve of the motor that enables us to effect this saving. In Fig. 30, horizontal ordinates represent amperes through the motor, and vertical ordinates represent values of the induction factor. We know that our motor must have *M* = 35.5 for 15 amperes, and *M* = 71 for 45 amperes. These values are shown by the points *b* and *f* in the figure. The point *a* is of course a third point

Now what does a straight induction curve mean? It means that the iron in the magnetic circuit is nowhere carried up to the point of saturation; in fact, it means that the only magnetic reluctance in the circuit is that of the air gap. This involves large cross-sections of iron, and consequently greatly-increased weight, the increase being nearly proportional to the value of *M* for the maximum current of 45 amperes. If we used motors with *M* = 106 at 45 amperes we should reduce the heat to the lowest possible limit, 13×10^3 foot-pounds, as compared with 32.2×10^3 for *M* = 71. But we should

then have an initial acceleration of more than 4.5 f.p.s. per second, and this would exceed the limit at which the driving wheels slip. We must then choose such a value for M as will give us the greatest possible initial acceleration. For $M = 71$ the acceleration is 3.1 f.p.s. per second, which we may take to be the highest permissible value. The acceleration curve in Fig. 27 is obtained by a graphic method from the curve abf , in Fig. 30; the curve de is the corresponding curve of torque on a speed base.

You will remember that the value $M = 35.5$ for 15 amperes was obtained on the assumption that the velocity ratio was to be 4.78. If we take a larger value of v , say 7.15, the value of

The rolling stock of this railway consists of motor cars and passenger cars. The former weigh 62,000 lbs. and are 47 feet in length, the latter weigh 46,000 lbs. when fully loaded. The motor cars are mounted on locomotive trucks with 33 inch driving wheels and a velocity ratio of 3.18. I shall take the case of a train weighing 90 tons, consisting of one motor and three passenger cars. I shall suppose that we have to design motors that shall drive this train through a distance of 2,500 feet of level track in 100 seconds from start to stop. The tension of the line is 500 volts; the drop at full speed is limited to five volts. The resistance to motion is 614 lbs. horizontal pull per motor

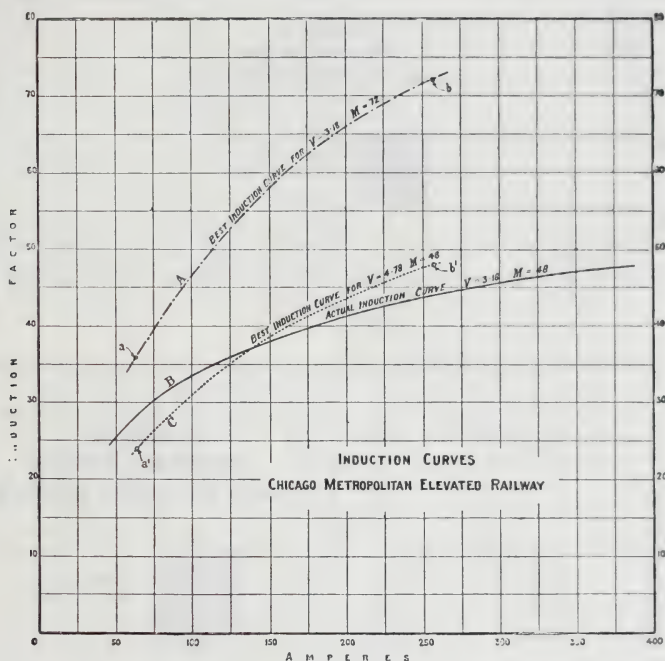


FIG. 31.

M at 15 amperes is reduced to 24. This is shown by the point k in Fig. 30. If we draw a straight line through ak it will pass through f . We have here then obtained a new induction curve with a different velocity ratio, giving us the same results as curve abc , but with a motor lighter than the former in the proportion of 4.78 to 7.15. Hence the larger the velocity ratio the lighter the motor. We must then take a value of v as large as is consistent with practical conditions of clearance, &c.

I propose now briefly to apply the principles which we have been discussing to a railway with which you must be more or less familiar, the Chicago Metropolitan Elevated Railroad.

when two motors are used, this resistance including the gear loss.

I shall assume that the train can be brought to rest in 20 seconds in 500 feet, leaving 2,000 feet to be covered in 80 seconds. This gives us the final speed, from which we deduce

$$\frac{M}{d} = 3.46. \text{ Now } v = 3.18 \text{ and } d = 33$$

inches, so that we get $M = 35.9$, and the corresponding current at full speed is 63 amperes per motor, and the resistance, to give a drop of five volts, must therefore be 0.0795 ohms. We have thus found one point on the induction curve, shown at a in Fig. 31.

The accelerating current can be found from equation (2) which I gave you, and is 226 amperes. If we take M at the start twice

acceleration 1.27 f.p.s. per second, a value well within the practical limits of adhesion. Point b in the figure gives $M = 72$ for 257

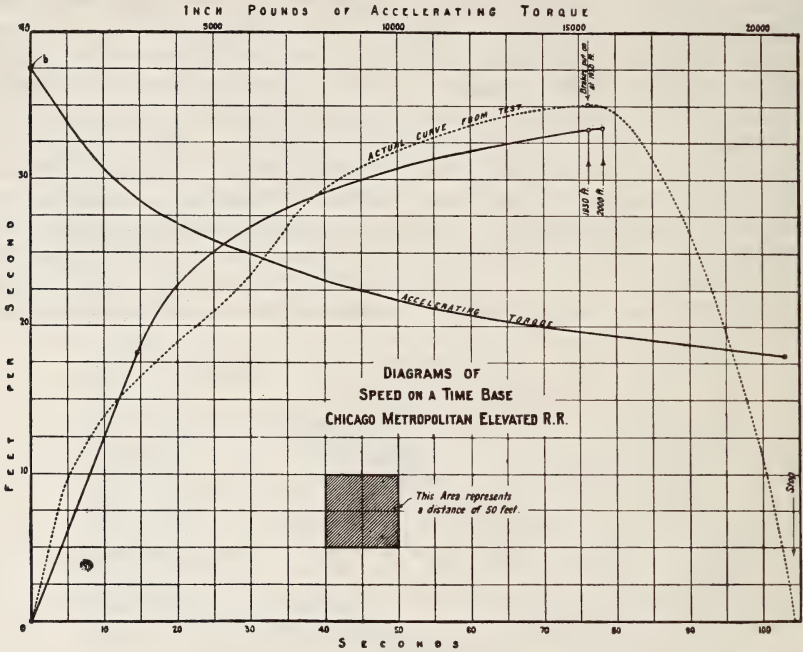


FIG. 32.

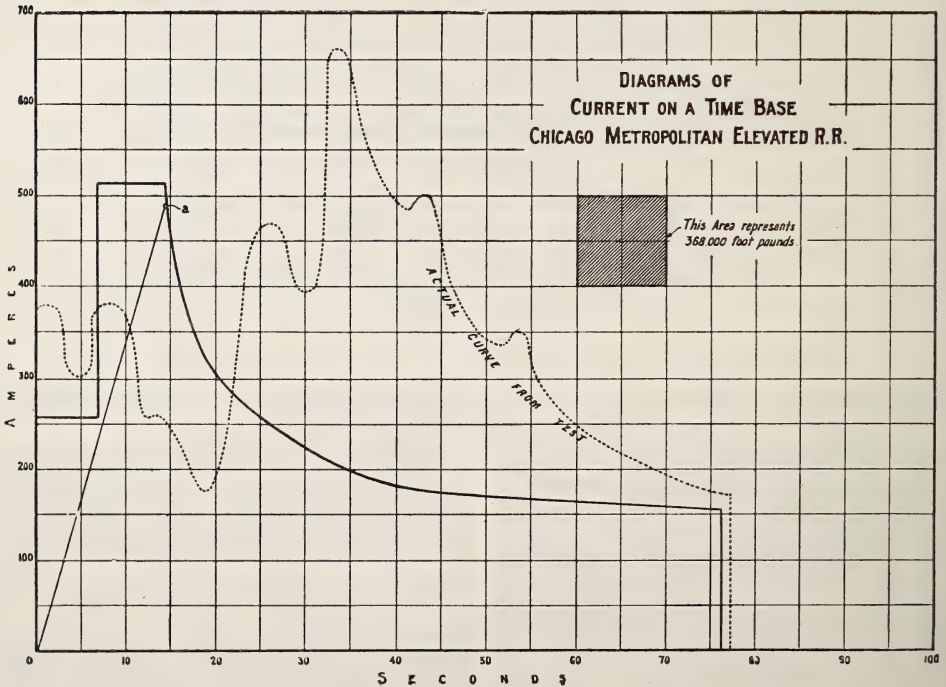


FIG. 33.

what it is at full speed, the frictional current at the start will be only 31.5 amperes, so that the total current is 257 amperes, and the initial

amperes. The curve $a b$ then is the required induction curve.

In Fig. 32 you see the curve of acceleration

obtained by a graphic method from the induction curve in Fig. 31; that is to say, if the train was fitted with motors having this induction curve, it would speed up in the way indicated by this acceleration curve. You see that the area of the curve represents almost exactly 2,000 feet at 80 seconds. The dotted line in this figure gives the acceleration curve as actually obtained in practice, from an experiment with a train of equal weight.

From the acceleration curves, you might suppose that the performance of the motors actually used was very much like that of those we have been designing. If, however, you look at Fig. 31, you will there see the induction curves of the motors actually used, given in the curve B. You see that this curve is quite different from A, the calculated induction curve. You may reasonably ask how it is that two motors with such different induction curves give nearly identical results? The answer is to be found in a comparison of the respective current curves. These are given in Fig. 33, the full line is the calculated curve, and the dotted line that obtained by experiment, corresponding to the experimental acceleration curve of Fig. 32. Series-parallel control is used in both cases.

You can see at a glance that the area of the actual curve is much greater than the calculated curve, the values expressed in foot-pounds, being 963×10^4 respectively. This great difference is explained by the fact that the values of M for large currents in the actual motors are not much more than half of those calculated, hence in order to get the initial acceleration necessary to carry the train through the given distance in the given time, far greater currents have to be used. Thus, on the series step the current per motor is 380 instead of 257 amperes, while the current from the line on the parallel step is 660 instead of 515 amperes. The expenditure of energy in the two cases is 85 and 60 watt-hours per ton-mile.

By reducing the vertical ordinates of curve A in Fig. 31, in the proportion of $3:18$ to $4:78$, we obtain a third curve, C, which is the induction curve for motors, which will give the same results as curve A, but with $v = 4:78$ instead of $3:18$. This new curve, C, very nearly coincides with curve B, that is to say, the motors in actual use would work with nearly the same economy as those calculated, if the velocity ratio were increased from $3:18$ to $4:78$. You see then how important it is to determine the right velocity ratio. In fact, we come back to

the point on which I insisted at the outset, that the problem before us in designing for rapid acceleration involves a careful consideration of the proper proportions of the whole equipment, and that the economy of running may be increased greatly by giving attention to the principles underlying the action of the motors in these peculiar circumstances.

I hope you will not imagine that I have referred to American practice, simply in order to criticise. The Americans have made immense strides in electric railway design during the last few years, far in advance of anything that has been done in this country. We should make it our aim to do even better than they have done. To this end we should carefully examine their designs, and get all the benefit we can from their experience, learning as much from their failures as from their successes.

Miscellaneous.

SLAG BRICKS IN GERMANY.

An interesting report has recently been issued in Germany on the manufacture of bricks from granulated blast furnace slag. The direct production of building and paving stone from fluid slag is, according to the United States Consul at Barmen, no new thing. Such slag bricks, however, did not prove a suitable material for dwelling-houses, because, like glass, they are impermeable for air as well as steam. In human habitations the aqueous vapour exhaled by the occupants would condense on cold days on both windows and walls, thus rendering the rooms damp and unhealthy. On the other hand, brick manufactured from granulated blast furnace slag is permeable and hygroscopical—that is both air and steam can penetrate them. The first person to produce granulated slag or slag gravel for brickmaking, by passing the fluid slag through water, was Eugene Langen, an *employé* of the Friedrichs Wilhelm mine near Siegburg, Westphalia. This process causes disintegration; silica is separated in a soluble condition in which it easily hardens in the air and combines just as easily with caustic lime. The single grains of this slag gravel when compressed tightly, are bound by the soluble silica; and when ground to a fine dust, so that the particles come into closer contact with each other, the binding by the silica therein is sufficient for the production of good building bricks. Bricks from ground slag, however, require a longer time for hardening than those manufactured from granulated slag. By mixing granulated slag with dust from slag which has crumbled in the air, good bricks can be produced without any addition of lime, but the hardening process is rather slow.

Hardening takes place quickest in from six to eight days with bricks to which about 10 per cent. of burned and slacked lime has been added. Granulated slag, from its passage through water, contains from 19 to 33 per cent. of water, according to its porosity, a fact which has to be considered in shipping. Its weight ranges between 1,100 and 1,500 lbs. per cubic meter (35·3 cubic feet); that of ground slag runs as high as 2,900 lbs. Ground slag can be added to the mixture of granulated slag and lime when especially dense and strong bricks are to be produced. The bricks may be given any shape desired, and they will preserve this shape because they are not burned. They show sharp edges and smooth surfaces, and give the greatest satisfaction when as little mortar as possible is used. The natural colour of slag bricks is that of greyish white sandstone. The weight ranges, according to dryness and slag used, between $6\frac{1}{2}$ and 7 lbs., or about 6,000 bricks to a 20-ton car. The strength of slag bricks fully equals that of ordinary burned bricks; 24 to 28 lbs. per square centimetre (square centimetre equal ·155 square inch) is usually considered the highest admissible burden for ordinary bricks. Well hardened slag bricks can withstand, theoretically, burdens up to 160 to 180 lbs. The resistance of slag bricks to high temperature is quite remarkable. Heated to a pale red when the carbonate of lime begins to decompose, its strength will not be injured. Even if a part of the lime should be decomposed at such a high temperature and thus rendered caustic, carbonic acid is again absorbed at a lower temperature, and the brick again becomes as strong as it was before. For the construction of chimneys and stacks slag bricks are used with advantage, as the products ascending contain a large quantity of free carbonic acid which is delivered to the bricks. For the same reasons it is well adapted for lining lime kilns and walling in boilers. Slag bricks are five times as permeable as ordinary burned bricks. Their porosity is also greater than that of burned bricks, and while they do not absorb water as quickly as burned bricks, they regain their permeability more quickly than the latter. At a recent trial, a burned brick filled up its pores with water in 12 hours, while a slag brick required 190 hours to get thoroughly soaked. To test whether slag bricks have dried and hardened sufficiently to be safely used, a small piece of brick tied to a string is dipped into a cold, concentrated solution of sulphate of soda and hung up at any place in a room. By the evaporation of the water in the solution, and the crystallisation of the soda, which in its action resembles the formation of ice, bricks which will not resist frost are destroyed, each crystal needle carrying a little cap of the material from which the brick was produced. Not slag bricks alone, but any other, can be tested in the above mentioned manner as to their power of resistance to frost. It is said that slag originating from puddling and Thomas pig iron produces the best bricks, while Bessemer and foundry slag ranks second. The erection of a slag brick plant in connection with a blast

furnace would cost about £1,000. At several German works the cost of production of about 1,000 bricks is only 10s. From 6,000 to 7,000 lbs. of granulated slag and 450 to 700 lbs. of burned lime are required for the production of 1,000 bricks.

General Notes.

AGRICULTURAL EXHIBITION AT WARSAW.—An Agricultural Exhibition will be held in the Museum of Trade and Agriculture, at Warsaw, from November 28th to December 5th of this year. The various sections will be :—*Section a.*—Seeds and roots shown in fifteen classes. *Section b.*—Cheese and butter. *Section c.*—Honey and bee-keeping appliances. *Section d.*—Flour, macaroni, chicory, starch, &c. *Section e.*—Fruit, wines, jam, preserved fruit, vegetables, meat, &c. *Section f.*—Weaving, pottery, basket-making, articles made of wood, straw, &c. *Section g.*—Agricultural machines and implements, artificial manures, harness, &c. The prizes are only open to Russian subjects, but foreigners can exhibit at the show. Application for space must be sent to the Museum of Trade and Agriculture, Krakowskie Przedmiescie 66, Warsaw, not later than October 20th.

WESTERN AUSTRALIAN EXHIBITION.—It has been decided to hold an Exhibition in Coolgardie next year, and the Government of Western Australia has resolved to support the undertaking by a money and land grant. The original proposition was to hold a mining machinery exhibition, and to open the same in October, 1897, but the scope of the Exhibition was enlarged, and it was determined to call it the Western Australian International Mining and Industrial Exhibition. Its objects are to obtain the fullest and best possible display of mining and other machinery, and of all kinds of manufactures suited to the requirements of the mining, timber, and agricultural industries of the colony, and to its growing population. The Government of the colony has agreed to frank all exhibits from the port of arrival, to and from Coolgardie, over their railways, and to treat the Exhibition buildings as a bonded store, so that no charges will be made for freight or Custom dues excepting on goods sold in the colony. The Exhibition will be opened on March 21, and will remain open for at least three months. Arrangements for Great Britain and the Continent are in the hands of the Special Commissioner, Mr. E. T. Scammell. Certificates of merit will be awarded in every section, special certificates being given for exhibits showing superlative merit. The Agent-General for Western Australia, the Hon. E. H. Wittenoom, as one of the patrons of the Exhibition, has undertaken to supply information from his office, Victoria-street, Westminster, to intending exhibitors and others.

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Proceedings of the Society.

CANTOR LECTURES.

SOME PRINCIPLES OF FORM-DESIGN IN APPLIED ART.

BY HUGH STANNUS, F.R.I.B.A.

Lecture I.—Delivered February 14, 1898.

ART may be defined as that branch of mental activity the intention and result of which is to make the material Environment-of-life more pleasant. When the things and acts which constitute this environment are most pleasing to minds of most intelligence—then they are said to be “beautiful”. The Beauty may appeal through any of those channels of communication from the Environment to the Mind, which are termed “the five Senses”; and may be beauty in Sight, Sound, Smell, Touch, or Taste. And, according to the particular Sense it affects, it will be beauty in:—Shape or Form and Colour, Sound, Odour, Taction, Savour. Opinions are divided on the question—of the intellectual order in which these should have precedence; and they are here arranged on the principle of Distance *v.* Proximity, it being assumed that those Senses which require *nearness* are more personal to the animal portion of the observer, and those which can be exercised on *distant* objects are appreciated by the intellectual faculties.

There is an Art (or several Arts) which appeals to each particular sense; thus:—Architecture, Sculpture, Painting, &c., to sight—Poetry, Music, &c., to sound—Perfumery, &c., to smell—Texture to touch—and Gastronomies to Taste; but only the first three, which appeal to the sense of Sight, are included in this present course.

A further subdivision is made—between the art that is produced without special reference to the surroundings, which is independent, isolated, unapplied, and sometimes heterogeneous or unsuitable—and the art which is

made *for* its place and *in* its place, is applied, and should be homogeneous and appropriate. The former may be termed “Independent-art”; and the latter is “Applied-art”.

The INDEPENDENT-ARTS are:—Sculpture, when the examples are made, each for its own intrinsic beauty in line and mass, without reference to the positions that they may afterwards occupy, but generally intended to be, each of them, the dominant feature of the Collection or Shrine. Some of these examples, like the Aphrodite of Knidos, the Nike of Melos, and the Apollo of the Belvedere are among the noblest achievements of man—Painting, when, similarly, the pictorial-artist shows his mastery over drawing colour and chiaroscuro, in subjects chosen to display those qualities without reference to or knowledge of any subsequent positions that may be dignified by the easel pictures; and, here again, it would not be difficult to name works which are immortal—Music, when the tone-artist feeling the throbbing of interwoven melodies, is impelled to score them without reference to any words—and so with the other Independent Arts: each of them is independent of any useful Object; and arises mainly out of the worker's joy in his powers.

The APPLIED-ARTS are:—Architecture, when interesting Variety, well-considered Proportion, refined Detail, and expressive Features are added to structures (as is so well shewn in Fergusson's History of Ancient and Mediæval Architecture, 1893, p. 13, and in Mr. Statham's Architecture for general Readers, 1895, p. 17.), which without such graces would be only Building—Sculpture, when the relief Frieze and Panel are applied as the decoration of a Cabinet—Painting, when the beauty of Foliage is applied to a Wall—Music, when the rhythmic beat of the military March is utilised to keep the soldiers in proper “step”—and so with the other Applied Arts: each of them owes its existence to the fact that it is *applied*.

This course is on Applied Art. Sir Edward Poynter, P.R.A., in his fine scholarly and searching “Ten Lectures on Art”, first published in 1879, has classified Applied Art into the two kinds, which are here termed:—Form-design, and Decoration-design.

FORM-DESIGN (or constructive design as he terms it)—“has its simplest expression in the form which a savage gives to the ordinary objects of his daily use; * * * to his hatchet, or to the rude vessels in which he cooks his food”.

DECORATION-DESIGN is seen—“in the

patterns which he cuts on the prow of his boat, or traces with a stick on his pottery, or the mud walls of his hut”.

The FORM of an object, and the DECORATION of that Form—are often conceived-together or simultaneously in the Artist’s mind, analogously to the close relation between the PLAN of a Building, and the ELEVATIONS of the Walls that enclose that Plan. Practically, however: the Plan for accommodation is first considered; and the Wall-design depends upon it; and similarly in Art: the Form (or, at least, the general Mass-form) is primary, and the Decoration is secondary. Thus a Pot is: (firstly) thrown on the Wheel, in which operation it receives its Form; and (secondly) scratching, painting, or modelling, is added or applied, in which operation it receives its Decoration.

There are cases, in which:—(a) the Function of the object does not permit of Decoration, or (b) the Beauty of the form does not require any further addition; but these will be considered, generally, as they arise. For the present, it will be well for the Student to consider the two operations as distinct; and to deal firstly with FORM, and secondly with DECORATION.

In Form-design the artist considers the design for the intended object, after the general conditions have been formulated according to the requirements of Fitness (*i.e.* fitness: to the Function or intended purpose and use of the object, to the Material of which the object is to be made with its capabilities and limitations, and to the particular Construction or methods of joining-together that he intends to adopt); and, always subject to these Conditions, he adds, according to his artistic individuality or “taste”, such further qualities as—Variety in the Mass-form, and Proportion of parts to each other and to the whole object.

These two qualities—Variety and Proportion—when superadded to the Fitness are sufficient in themselves to render an object beautiful. Further artistic work may impart other qualities, *e.g.*:—Richness, Refinement, Accent, &c.; but they are not absolutely necessary. One Vase with Variety and Proportion superadded in the Form, though without any decorative detail, may shew a high order of Beauty; while, in another of bad Form, the faults may be a little disguised by judicious Decoration, but they can not be eradicated; and it will always be low in the scale.

The two Branches of any treatise on Applied

Art are: (1) the Elements, and (2) the Principles which govern the application of those elements. In the sister-art of Gastronomics, the Cook manipulates and mingles certain Ingredients according to certain Recipes; and the student will perceive the analogy between the Ingredients and the Elements, and between the Recipes and the Principles.

The ELEMENTS of FORM are the Geometrical Solids, *e.g.*: the Cylinder, Prism, Sphere, Ovus, Cone, Hyperboloid, Parallelo-piped, &c., and many Irregular forms which need not be particularised here.

The ELEMENTS of DECORATION are Geometrical Lines and Figures, Ornament (see the author’s second course of Cantor Lectures on “Artificial Foliage”), Natural Foliage (see the author’s first course of Cantor Lectures on “Natural Foliage”), Artificial Objects (*e.g.* the Garland, Shield, Festoon, Tablet, &c.), Parts of Animals (*e.g.* the Lion-head for the Water-spout, the Lion-leg for the Foot-stool, &c.), Animals and Compound-animals (*e.g.* the Lion, Gryphon, &c.), and, lastly, the Human-figure, which is the noblest of all. All of these, except the Human-figure, will be seen in Meyer’s “Handbook of Ornament” (2nd English edition, Batsford, 1894).

A PRINCIPLE, in ordinary language, is the underlying universal consideration which governs conduct in Daily-life, *e.g.* the “Golden Rule”. The essence or spirit of this is expanded, embodied, and applied in detail to particular Places; and this application is termed a By-law. It is further expanded, in more detail for particular Persons; and this is termed a Rule of Etiquette.

The PRINCIPLES in APPLIED ART are analogous; but, by an unfortunate looseness of idea, in some lists of Principles, there has been no distinction made between the universal Principle (that is right under all conditions) and the local Law (that is limited in application, and subject to be suspended in operation by the higher); nor between these and the minor Rule (that is applied only to the small details in their “personal” relation to each other);* and the indiscriminating Dogmatism, that makes the less of as much importance as the greater, has caused a hostile feeling against all principles, and a desire to “kick over the traces” in the restless and capricious search for so-called “Novelty”.

* See this beautifully expressed in “the Education of the World,” by Dr. Temple (the present Archbishop of Canterbury) published in “Essays and Reviews.”

These Principles are :—Fitness, Variety, Proportion, Sympathy, Expression, &c. It is impossible, within restricted limits, to do more than mention their importance ; and it may perhaps be more useful to the student if his attention is directed to the Laws.

The FUNCTION of any object or feature of an object is the intended Purpose or Duty that it is arranged to serve or sustain, *e.g.*—the retaining of the Stems in a *vertical* attitude, by the Flower-vase—or the permitting of an *easy* flow of Liquid, by the Teapot-spout. Sometimes several Functions are served by the same object, *e.g.* in the Greek water-vase termed the Hydria (the first sketch in fig. 2) a vessel that—(a) the women carried in a horizontal attitude resting in an annular Pad on their heads, in going to the Spring ; hence its largeness and roundness of profile at the centre of gravity (empty) near the widest part of the vessel—(b) was held by the women under the bubbling flow ; hence the large and strong single Handle attached to the neck—(c) had to catch as much water as possible ; hence the wide Mouth—(d) had to be lifted by each woman to her head ; hence the two Side-handles—(e) had to be steady when carried in a vertical attitude on the head ; hence the strong wide Foot—(f) had to prevent splashing as the woman walked ; hence the contraction from the vase-shoulder to the vase-neck. So, also, in the oil-vase termed the Lekythos (the second sketch in fig. 2), the vessel was—(a) small and suspended from the girdle ; hence the small strong Handle—(b) was used by the athletes for anointing themselves ; hence the swelling-out of the neck for the purpose of forming a Cup (as shown by the dotted lines) from which the finger might easily extract a small quantity as required. The Greek Vases, of the great period, are so perfectly beautiful in their Form that the spectator is liable to overlook or not to appreciate the no less perfect fitness for their Function.

Objects are FUNCTIONALLY-DESIGNED when all the Purposes or Duties for which they are intended are properly considered and provided-for. The quality, that is thereby conferred upon the object, is termed Functionality.

The Law of FUNCTIONALITY is the first and the most important in Applied-Art. It prescribes that the Form shall be such as will best serve the intended Purpose of each object. No desire for Variety, in bulk, curvature, or texture, may be permitted to interfere with this. Nor should *Vis inertia* or indolent Pleading of Custom be allowed to prevent the student

from searchingly considering each function of each part. And no amount of clever handicraft can atone for neglect of this primary Law. In a competition for a Foot-scraper to be executed in Cast-iron, some years ago : one of the models shewed two cupids, about 6 ins. high, holding a *piece of Drapery*, like two maids shaking a carpet, against the upper edge of which the foot was to be scraped ! The two cupids were very good examples of modelling ; but the artist appeared to have overlooked the fact that the problem was :—not to model a cupid, but to design a Foot-scraper. The result was ridiculous as a Design and disastrous for him ; and many of the objects that vulgarise houses result from a similar ignoring of this first and greatest Law—Functionality.

DISREGARD of Functionality is shewn in the sketch (the first in fig. 1). The artist may

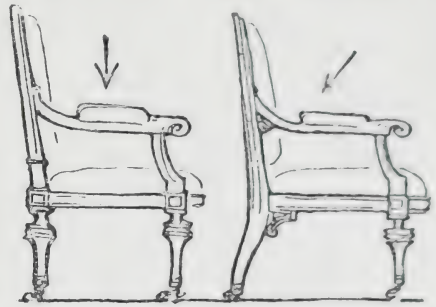


FIG. 1.

have thought that the strain on the chair was only *vertical* (shewn by the arrow), as it is on a Stool or a seat without a back. But, when a Back is provided, and the sitter leans against it ; the strain becomes *oblique* ; and this should be provided-for (as shewn in the second sketch). The first is from a set of chairs, beautiful in other respects, in one of the French Palaces : perhaps they have not been much used (now they are merely Show-objects) : if they had to undergo the wear and tear of daily life, they would soon exhibit, in the loose joints and rickety-ness, the neglect of the artist.

FUNCTIONALITY includes considerations relating to the Anthropic-size, the Ansation, and the Cleaning of Objects, and also to the Avoidance of Injury-to-the-user, and of Injury-to-the-object.

ANTHROPIC-SIZE is the average size of Man as governing the size of the Objects that he uses. Thus :—that of the whole body is necessary for the opening-space of Doors, &c., both in height and width—the height of his Breast

is necessary for that of Parapets—the height of his Knee-joint is necessary for that of Seats—the height of his Hand is necessary for that of Door-handles and Chair-backs—the size of his hand for that of Handles of Doors, &c.—the size of his fingers for that of Teacup-handles, &c.—the length of his foot for the breadth of a Stair-tread—and the length of his down-hill Step is taken for that of the Stair-riser and Stair-tread together.

DISREGARD of Anthropic-size is seen in the Steps round the Parthenon, and in other Temples. The height of the Riser and the breadth of the Tread are too great; hence, in some Temples, smaller Steps of anthropic-size were cut-out or interpolated at the entrances. When the Anthropic-size is considered in a building, in the Steps, the Seats, the Doors, and other parts: then the spectator can better assess and appreciate the Size of the building. The church of St. Peter's, on the Vatican Hill, at Rome is an instance of the manner in which the colossal size of the building loses its impressiveness by reason of the colossal size of the details and disregard of Anthropic-size.

ANSATION is important in all objects that are carried. The artist takes this into his thought, considering the number, position, attitude, &c. of the Handles; and so making them characteristic and expressive features in his design. M. Viollet-le-Duc, in the sixth of his fine analytic and suggestive "Entrétiens", 1860, shews the arrangement of handles when a Vase must be reversed for draining. Dr. Christopher Dresser, in his useful books: "The Art of Decorative Design", 1862, at pp. 133 et seq., and "The Principles of Decorative Design" (about 15 years later), at pp. 139 et seq., has reasoned-out the application of the Handle in relation to the distributing of liquid from the vessel. Two sketches of fig. 2 are adapted from his

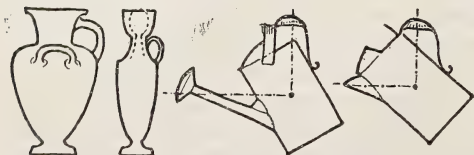


FIG. 2.

illustrations. The third sketch is for a *pipe-spout* Water-can; and the fourth sketch is for a *lip-spout* Water-can. In each case—the Centre-of-gravity of the vessel (when full) is found, as marked by the Dot in the two sketches. A Line (termed the Delivery-line) is drawn, from this Dot, to the lowest point at

which the liquid is delivered. From this Dot, and at right-angles to the Delivery-line, a Line (termed the Suspension-line) is drawn in an upward direction. When the Distributing-handle is on this Suspension-line, then the vessel is most easily manipulated.

DISREGARD of Ansation is seen in most Tea-pots: all who have to pour-out tea will



FIG. 3.

have felt the great disadvantage of the Position of the handles. Another example is



FIG. 4.

shewn in fig. 3 in which the Vase, described (among others) as being "in the highest sense

original generally from admirable designs by the great artists of Germany", is furnished with attached extraneous pieces of Ornament in such a manner that the would-be user can not hold it to drink-from, either by the Side-handles or the Stem-handle. The Vase is shewn in fig. 4 with the Ansation corrected. (It is necessary here to explain that this and nearly all the figures are from *rough sketches*, such as were made on the Black-board; and, beyond elucidating the Law involved, make no pretension to be Designs.)

All MOVABLE OBJECTS, which have to be lifted from one position to another, should either be ansated or be provided with some conspicuous Knob or plain portion that may be grasped with efficiency and comfort. When the maid is uncertain what she should take-hold-of for the purpose of lifting the chair or pulling down the chandelier—then the artist is in fault.

CLEANING, or provision for efficient and easy cleaning, is important in all objects that are used. The inside of the Jug, and face of the Mirror, will occur to everyone.

DISREGARD of this is seen:—in the elaborately-chased chamber-candlestick, that becomes clogged with overflowing wax—in the pot Jug with neck too small to admit the hand (if the artist plead that the smallness of the neck gives character to his design and that he cannot do without it: then he has mistaken his vocation)—in the carved Mirror-frame "decorated" by the Swag-festoons that overhang the Glass, causing the leaving of dirty places or the risk of breakage as each weekly Cleaning-day comes round—and more examples will occur to every Housewife.

INJURY to the USER must be foreseen and prevented, by the avoidance of sharp edges and spikey relief-work, and generally by the introduction of smoothness and softness, so far as is practicable, in all places within reach of Traffic or Use. Without going so far towards the other extreme as to provide Padded-rooms, the artist may yet take care, in these days of feverish hurry and rushing-about, that, in the Mouldings of Passage-ways, &c., and in the Metal-fittings of Doors, &c., there shall be no projecting blocks to "bark the shins" or "skin the knuckles" of the user.

DISREGARD of this will be seen:—in the Chair-back that tears the Lady's dress by its prickly ornament—in the wrought-iron support to the Wash-bason that becomes entangled in the dress—in the Screws of the Door-handle that are not "driven-home"—&c.

INJURY to the OBJECT by the Use must equally be avoided. An interesting example of this is seen at Pompei, where the arrisses shewing an angle of about 100° to 120° between the flutes of the Greek Doric Columns were damaged by the Traffic; and where, consequently, the flutes are filled-up with cement, making facets only, with arrisses of $157\frac{1}{2}^{\circ}$, which is much more obtuse, and therefore less liable to injury.

Miscellaneous.

A NATIONAL PHYSICAL LABORATORY.

The committee appointed in August, 1897, to consider the desirability of establishing a National Physical Laboratory have issued their report. The committee consisted of Lord Rayleigh, F.R.S. (chairman), Sir Courtenay Boyle, K.C.B., Sir Andrew Noble, K.C.B., F.R.S., Sir John Wolfe Barry, K.C.B., F.R.S., Prof. W. C. Roberts-Austen, C.B., F.R.S., Mr. Robert Chalmers, Prof. A. W. Rücker, F.R.S., Mr. Alexander Siemens, and Dr. T. E. Thorpe, F.R.S. The questions referred to them were as follows:—

"To consider and report upon the desirability of establishing a National Physical Laboratory for the testing and verification of instruments for physical investigation; for the construction and preservation of standards of measurement; and for the systematic determination of physical constants and numerical data useful for scientific and industrial purposes—and to report whether the work of such an institution, if established, could be associated with any testing or standardising work, already performed wholly or partly at the public cost."

The following extracts from the report of the committee are given by *Nature*:—

In general, the committee are of opinion that the appliances and facilities of the Standards Office and of the Electrical Standardising Laboratory are fairly adequate for the performance of their statutory duties. They understand, however, that on account of the want of means for the chemical analysis of the materials used in the construction of standards, those offices would find some difficulty, without extraneous assistance, with regard to any new standards that might be required.

They further desire to point out that many physical constants and data and numerical expressions are necessarily used in connection with standards and the standardising of instruments. Some of the data now in use at the Standards Office are known to require correction, and in the case of others further investigations appear to be desirable. There is, however, no legal obligation on the Board of Trade to establish

new data and numerical expressions, and, in consequence of the smallness of the staff of the office, the work of the Department is limited to that which is strictly enjoined by the Acts of Parliament. The Department is at the present time chiefly dependent for more exact knowledge on such investigations as may be undertaken at the Bureau International des Poids et Mesures at Paris, or by foreign institutions similar to that contemplated in this country.

There is much evidence that further facilities are needed by the public for standardising and verifying of instruments, both for scientific and commercial use; and also that it would be of great benefit to trade if means were provided for the public testing of the quality of certain classes of materials. In particular the committee desire to draw attention to the evidence which has been laid before them as to the difficulties arising in certain Government departments in their dealings with contractors and others which might be overcome by the establishment of an independent testing authority. It would neither be necessary nor desirable to compete with or interfere with the testing of materials of various kinds as now carried out in private or other laboratories; but there are many special and important tests and investigations into the strength and behaviour of materials which might be conducted with great advantage at a laboratory such as is contemplated in the reference. As illustrations we may mention investigations into the behaviour of metals and other substances under continuous or alternating stresses, which investigations are not, so far as we know, conducted at the present time at any testing institution in this country, and which could only be undertaken with satisfactory and authoritative results at a public laboratory.

For many years the testing of certain instruments has been carried out at the Kew Observatory under the direction of the Kew Observatory Committee of the Royal Society. There is much evidence that the existence of these tests has been of great benefit to both science and industry. On the one hand it enables the maker to give, or the purchaser to obtain, an independent and trustworthy statement as to the quality of the instrument. On the other hand, the existence of the tests has led in many cases to a marked improvement in the instruments; and similar results may be anticipated by an extension of these facilities to other branches of industry.

The Kew Observatory is a Government building leased to the Royal Society at a nominal rent, situate in the Old Deer Park, Richmond, which is Crown property. The institution has no endowment, the Gassiot Fund producing about £470 per annum. From the Meteorological Office it receives annually £400, part of which is the ordinary grant made to a first-class meteorological station, the remainder being for scientific assistance. The fees received for the verification and testing of instruments amount to about £2,000 per annum. The institution is self-supporting, and has usually a small annual balance which is devoted to scientific investigation and to the

extension of the work, including the erection of new buildings, when required. The funds at the disposal of the Observatory Committee are, however, quite inadequate to any considerable extension of its operations. The work done with restricted means has been very useful. The total number of instruments annually verified or tested is about 22,000. Among these are included watches, thermometers, sextants, barometers, and other apparatus used for scientific or industrial purposes. Evidence was given of the beneficial effect which Kew has exerted on the watchmaking trade, and it is noteworthy that this is due to the introduction of tests for which there was little or no previous demand on the part of the trade, though there is now keen competition among the best makers to secure a high place in the report which is annually issued.

In the opinion of the committee the principles which underlie the proposal for the establishment of a national physical laboratory have been tested on a comparatively small scale at the Kew Observatory with the most satisfactory results.

In addition to the physical constants and numerical data needed in connection with standards, there are numerous facts, a knowledge of which would be of great value to science and industry. The determination of such data usually involves an investigation as to the method of making the determination, and a considerable expenditure of skilled labour in carrying out the determination. The committee are of opinion that, although the former part of this work will in general be initiated by individual experimenters of great skill and originality, it may in special cases be usefully undertaken by a public body. It is rather to the improvement in the details of the method of making the determination that they think that the work of a public institution will for the most part be directed. This cannot usually be carried out by private investigators on account of the expense and the length of time over which the experiments must extend. The scientific reputation to be gained is often incommensurate with the labour involved; and even when the results are of industrial importance in many cases they cannot be protected by patents.

There is evidence that many questions of this nature are partially investigated for technical purposes by private persons, the results being not infrequently kept secret. More complete investigations, carried out at a public institution and freely published, would often be of great service to industry, and there is reason to believe that a large part of the cost of such work might be defrayed by the persons directly interested in the results.

One difficulty in connection with a scheme for the determination of constants and data arises from the fact that the number of subjects which might be pressed for investigation would be very large. The opinion was, however, generally expressed by the witnesses that a strong governing body would have no difficulty in selecting those branches of work which were the most important, and that it would be

possible to confine the work of the proposed institution, if established, within moderate limits. Nearly all the witnesses, also, have expressed the opinion that those interested in industry as well as persons devoted to the study of pure science would be willing that the Royal Society should be ultimately responsible for the management of the proposed institution, provided that industry were adequately represented on the governing body, and that the choice of the members of that body, though nominated by the Council of the Royal Society, were not confined to Fellows of the society.

After consideration of the evidence, the committee have come to the conclusion that an institution should be established for standardising and verifying instruments, for testing materials, and for the determination of physical constants. Work useful both to science and industry could therein be performed for which no adequate provision is at present made, either in this country or at the Bureau International des Poids et Mesures. Such work could not, or, at all events, in all probability would not, be undertaken by individual workers, or by institutions primarily devoted to education. In the opinion of the committee the proposed institution should be established at the national expense on lines similar to, though not at present on the scale of, the Physikalisch-technische Reichsanstalt. The possibility of future extension should, however, be kept in view from the first.

To secure the efficient performance of the work, the committee are of opinion that the director of the institution should be a man of high scientific attainments, and should act under a governing body containing representatives of both science and industry. The director should not be called upon or allowed to undertake work not connected with the institution, except with the consent of the governing body. He would require the support of an adequate staff. As regards locality, while it is desirable that the institution should be near London, it is necessary that the site be free from mechanical and electrical disturbance.

Among the most important questions considered by the committee was whether the proposed institution should be founded independently or should be a development of an existing institution. The duties of the Board of Trade, as custodian of certain standards, are defined by statute, and the committee consider that it is undesirable to alter existing arrangements in this respect. They are of opinion that the proposed laboratory, if established, should be managed by a governing body constituted and appointed as hereinafter described, and should not be under the direct control of a Government department. They recommend that the Board of Trade, as custodian of the standards, should be placed in close connection with the said governing body.

The character of the work done at the Kew Observatory suggests that all that is really necessary might be attained by the development of that institution.

RECOMMENDATIONS.

(1.) That a public institution should be founded for standardising and verifying instruments, for testing materials, and for the determination of physical constants.

(2.) That the institution should be established by extending the Kew Observatory in the Old Deer Park, Richmond, and that the scheme should include the improvement of the existing buildings and the erection of new buildings at some distance from the present observatory.

(3.) That the Royal Society should be invited to control the proposed institution, and to nominate a governing body, on which commercial interests should be represented, the choice of the members of such body not being confined to Fellows of the society.

(4.) That the Permanent Secretary of the Board of Trade shall be an *ex-officio* member of the governing body, and that such body shall be consulted by the Standards Office and the Electrical Standardising Department of the Board of Trade upon difficult questions that may arise from time to time, or as to proposed modifications or developments.

FLAX CULTURE IN THE UNITED STATES.

The historical records of the United States show that flax culture was one of the earliest of colonial industries, and until comparatively recent years the culture and manufacture of flax in America have been household industries. American colonists brought with them the art of raising flax and of preparing and spinning it by hand, and even fifty years ago the custom prevailed among farmers of growing flax and having it retted, scutched, hackled, and spun by members of their household. In the history of Lynn, Massachusetts, it is stated that about the year 1630, "they raised considerable quantities of flax, which was retted in one of the ponds, thence called Flax Pond." As early as 1662 the State of Virginia enacted that each poll district should raise annually and manufacture six pounds of linen thread. All the records of New England also give evidence of an earnest desire to promote the cultivation of flax and its manufacture. In a report to the United States Department of Agriculture by the special agent in charge of the office of fibre investigations, it is stated that about 1778, a number of colonists arrived from Londonderry, bringing with them manufactured fabrics of linen, and the implements used in their manufacture in Ireland. The matter was earnestly taken up by the Bostonians, and a vote passed to establish a spinning school. About 1721, at Newport, Rhode Island, "hemp or flax used to be received in payment of interest, the former at 8d., and the latter at 10d. per pound." Pennsylvania offered premiums for several grades of linen thread in 1753, and the Society for the Promotion of Arts, Agriculture, and Economy, of New York, after adopting resolutions to

arrest the importation of British goods, offered premiums for linen thread. The early records of Rhode Island develop further interesting facts concerning an association of plantation maidens about 1766. The order was known as the Daughters of Liberty. It is not necessary, however, to go back a hundred years, or even fifty years, to learn the story of American household linen manufacture, for a remnant of the industry still exists in the mountains of Virginia, North Carolina, and Tennessee, and an interesting series of the fabrics made in these localities in recent times has been secured for the United States National Museum. Sixty years ago, about 750,000 pounds of flax fibre were produced in the United States, and flax was sent to market from Connecticut that was as strong and as good as any raised in the United States at the present time. Very strong and flexible flax also came from northern New York and Vermont, but it was not clean. The poorest flax of those days came from New Jersey, although it is said that that State has been capable of growing flax equal to that of Archangel. At the present time flax is largely grown in the United States for seed, the straw, of inferior quality, when used at all going to the tow mills or the paper mills, and being worth from 4s. 2d. to 3s. 4d. a ton. In the older States the area under present cultivation is very small and is steadily decreasing. In the newer States, or States where agriculture is being pushed steadily westward from year to year, the area under cultivation about holds its own taking one season with another. Cultivation for fibre is beginning to attract attention however, and the Department of Agriculture is striving to re-establish this important industry in the United States. By experimentation in fifty or more localities in the United States where flax cultivation was thought possible, the Department has proved the fallacy of the opinion widely prevalent less than a decade ago, that flax could not be produced commercially in the United States. By these experiments it has not only been proved that commercial flax production is possible, but that good fibre and good seed with careful culture can be produced in the same plant. The most important results have been obtained on the Pacific coast, where, as in the Puget Sound region of Washington, an ideal flax climate has been discovered. Experiments here have shown that for flax culture the Puget Sound region is the equal in climate to some of the best flax-producing regions of Europe. The superior quality of straw produced, which resembled the straw of the famous Courtrai region of Belgium attracted the attention of the Barbour Company of Lisburn, Ireland, resulting in this firm undertaking a retting experiment in Ireland with a ton of Puget Sound straw. The experiment demonstrated that it is possible to produce very fine fibre and good seed in the same plant. It is stated that if the flax is grown and manipulated under proper conditions, and by people who thoroughly understand their business, in Puget Sound, the cultivation of it would be of the greatest importance, and in a short time would rival

the great Belgian district of Courtrai. The flax plant is now widely distributed throughout the world. It is cultivated in portions of South America, especially in Argentina, though more for seed than for fibre. It is produced commercially to a greater or less extent in Great Britain (Ireland especially), Sweden, Denmark, Holland, Belgium, France, Holland, Germany, Austria, Spain, and Portugal. It has been introduced into Algeria, and into Natal. In India large tracts are under cultivation, though more for the seed crop than for the fibre. Japan has introduced its cultivation commercially, and it has been experimented with in the Australian colonies, where there is a wide range of soil and climate suited to its growth. The special agent of the Department of Agriculture says:—"There is no doubt about the ability of the inhabitants of the United States to grow commercial flax if the people will only make beginnings, and go to work in earnest with the idea in view first, to establish the industry, and to make money out of it afterwards. The time is ripe for the establishment of the industry, as is proved by the profound interest that has been awakened in our experiments by foreign manufacturers."

OLIVE AND VINE CULTIVATION IN TUNIS.

The olive tree promises in the future to become the most important asset of the Regency of Tunis. The wild olive is indigenous to the mountains of North Africa, and it is quite possible, says Sir H. Johnston, H.M. Consul-General, that its cultivation by man commenced in Tunis. There are said to be about 12,000,000 olive trees in Tunisia. The cultivation of olives has greatly increased since the French occupation. The soil which is thought to be the best for the cultivation of the olive is gravelly or sandy soil on a rocky subsoil. Clayey land is thought to be bad. The method of cultivation is as follows:—Holes of about one foot and a half in depth are dug at intervals of about 24 yards. This is done at the commencement of the autumn so that the autumn rains may soak the ground. The holes also are arranged in such a manner that they shall be situated on squares of 24 yards every way, every effort being made to get them in irreproachably straight lines. Cuttings are then made from the trunks of old olive trees. These appear to be pieces of wood about ten inches long and four inches thick retaining on one side the bark. If possible these pieces are cut from the trunk of the tree below the ground. They are usually purchasable at twenty shillings the 100. These cuttings may remain as long as two weeks exposed to the sun, so that their transport is very easily effected from place to place. If, however, it is desired to keep them for even a longer period they are temporarily buried in the soil. Planting takes place between December and March, and if insufficient rain falls the holes are well irrigated. The cutting is placed at the bottom of the hole with-

out manure; earth is pressed round it and thrown loosely on the top to a depth of about ten inches. In the spring time the young shoots begin to appear, and the filling up of the hole is left to the wind and to the passage of the plough up and down the avenues between the trees. Young plantations are irrigated three times during the summer of the first year and sometimes during the second year. During the ten years' growth of the young olive tree, it is prudently pruned in such a manner as to give it a well-balanced, rounded form, with the principle branches at fairly equal distances, so that the air may circulate easily between them. Up to the sixth year of the plantation other cultivations are carried on between the olive trees, such as barley or beans. After the sixth year, however, no further cultivation takes place between the olives, for which henceforth the land is exclusively reserved. The commonest species of olive tree which yields the most oil, is called by the Arabs, "Shemlali." This variety is never grafted, but on to the Shemlali stock are often grafted other varieties, such as the "Mellahi" and the "Nab," and another kind called the "Nab Reshid." The Shemlali is the kind mainly used for making olive oil, the other sorts are for the table and for eating. The best table olive is the Mellahi, the fruits of which are nearly the size of a small apricot. It is this variety which is chiefly exported to Europe for salting and bottling. Olive trees begin to bear fruit sometimes in the third year of growth. At six or seven years old the trees may give as much as two or three quarts of fruit, but the true regular yield does not commence until they are ten years old. Fine trees, twenty years old, may have a yield of 200 quarts of fruit per annum. The olive tree blossoms in April and May, and the fruit is ripe in October and November, but the harvest is not over till the end of January. The olive varies in the extent of its productiveness. Two full harvests are never gathered from the same tree on two successive years. It is considered that three years give about the average yield of a tree, one good year, one medium, and one bad. The olives coming from very young trees give under the mill 10 per cent. of their weight in oil. As the trees increase in age, so the yield of oil from the fruit increases likewise, until, when the olive tree has reached its prime, the crushed fruit may give 18 to 20 per cent. of its weight in oil in the Arab mills, and as much as 30 per cent. in the oil presses of European construction. The olive would appear to attain an indefinite age, stretching beyond the present limits of human experience, and its productiveness has likewise no limit. It is said, however, that after 50 years, there comes a period when the yield of fruit diminishes, and that the Arabs then restore vigour to the exhausted tree by means of pruning and manure. The present annual production of olive oil in Tunisia exceeds 20,000 tons, estimated at a value of £600,000. As regards viticulture, the production of wine from the vineyards of the Regency in 1895 reached the figure of 3,762,000 gallons. In 1896, on account of

the drought, it sank to 2,662,000 gallons. The average value of the yearly export of wine is £80,000. There are said to be more than 17,250 acres of vineyards devoted to wine making. Tunisian wine is chiefly of good quality, and the red wines do not suffer deterioration from transport, though the most delicious wine of the country—the white muscat, very sweet and of delicate flavour—would not stand being kept long, or being exported without turning into vinegar. The amount of alcohol in Tunisian wines varies from 8 to 13 degrees. There are said to be five varieties of grape at present grown in Tunis, apart from those which have been introduced from America. The most esteemed is the "Asli," which is a round white grape with fine skin, very rich in sugar. There are two other white and yellow-white grapes with slightly wrinkled skins. Of the two varieties of black grape grown in Tunis, one is of the colour and appearance of Black Hambro', and the other is a small grape of a deep red colour. The best grapes come from Sfax. The more or less Berber inhabitants of Tunis—the natives of the islands of Jerba and Kerkna, and elsewhere—made and drank wines from their grapes before the institution of regular vineyards, subsequent to the French protectorate; but amongst the stricter Mohammedans, grapes were only grown and sold as fruit. There are now numerous vineyards along the north and east coasts of Tunis belonging to Europeans—Frenchmen, two or three Englishmen, Maltese, and Italians. A few raisins are prepared and sold locally, but they are not sufficiently remunerative to be exported. Raisins are, however, in great demand in Tunis, and figure considerably in the imports from foreign countries. It is said that the vineyards round Sfax will always be able to resist the phylloxera on account of the peculiar gravelly soil. Up to the present this pest has not made its appearance in Tunisia. It is said also that the cultivation of the vine might be extended far more widely over the Regency. It would probably grow very well on the Matmata Plateau. Pliny, in his "Natural History," praises the wine which was grown in the Tripolitaine as amongst the best reputed in the Roman Empire. Vines grow luxuriantly under the palm trees in the oasis of the Jerid, but are merely cultivated there for the fruit they produce.

CONSULS AND TRADE.

The following article on the important questions relating to the criticisms of Consuls on British merchants, and on the influence of British Consuls on the promotion of trade, is taken from the *Engineer*:—

For years past, as all our readers are aware, the British Consul in every country where a Consul can exist, has censured British methods of trading, and told the manufacturer and the merchant that his arrangements for selling his wares are unpractical, unsuitable, and wholly defective as compared with

the methods in vogue with our rivals. We cannot call to mind a single instance in which a British Consul has a good word for a British trader. It is true that in a very limited number of cases it is admitted that the Englishman pushes trade better than the German, but that is only because of some wholly abnormal laxity on the part of the German trader; and such admissions only seem to accentuate the censure which we have come to expect as an essential feature of a consular report. The concession that a man may occasionally do what is right imparts an air of fairness and impartiality to the actions of those who wield the lash with no unsparing hand. An old proverb tells us, however, that it is "a long lane that has no turning," and the turn seems to have come at last. The British trader is beginning to retaliate, and even to assert that much of the success of our competitors is due, not to the British trader, but to the British Consul himself. Some note of this contention has reached us during the last few weeks, and particularly in one case, wherein we are assured that the British trader seeking information has had to apply to the German Consul for it, the British Consul being wholly unable or unwilling to help him. We have no doubt that the statement is quite true, though we are not disposed to attach over much importance to it. On the 29th ult., however, an evening contemporary published a long article, which in no measured terms denounces, not so much the British Consul, as the British consular system. We cannot, perhaps, do better than quote the following passage from the *Pall Mall Gazette* to make the essence of its attack intelligible. Speaking of other nations, our contemporary writes:—"France, Germany, and America have perfectly equipped services. They have considered the importance of the question, and the serious issues resulting from it as far as their commercial interests are concerned. They always fill their consular posts with natives of their own country, and they make a particular point of locating them in places where their services would be of the most advantage to the country they represent."

A meeting of the Grosvenor-house Committee was held lately to hear a paper read by Mr. Edward Atkin on "British Consular Appointments in Turkey." After a discussion, the following resolution was passed unanimously:—"That the following recommendation to his Grace the President be submitted for transmission to the Prime Minister: 'The committee desires to call attention to the mischievous effects of the system of employing in the British consular service men who are connected, either directly or through relatives, with local commercial enterprise, and who are in consequence unable to act and speak with firmness in affairs vitally affecting British interests. It urges upon her Majesty's Government the importance of appointing at least one-half of the Consuls and Vice-Consuls in Turkey from officers of the Army or Navy who are linguistically qualified.'"

The whole subject is one of very great importance,

because a Consul has, or ought to have, a great deal in his power. Although we hold that our consular service is not perfect, we are by no means prepared to go far on the road of censure with our contemporary. Nor can we believe "that the scandal is growing in its dimensions, and foreign consular services, which are built on a firm financial basis, are doing a work which is both creditable to themselves and a shame to us." We are prepared to admit that our consular service is open to improvement; but it would require very strong evidence to make us believe that our service is very far behind that of other nations. The duties to be discharged by a Consul are very numerous; in many cases very onerous, and never overpaid. He is supposed to be the grand centre of reference to whom every Briton in his district is to turn for help and information under the most varied conditions. The Consul is supposed to know everything that no one else knows, and to possess unlimited influence. His wisdom is known to pass the wisdom of Solomon, and his integrity must be absolutely unimpeachable. To him runs every Briton in distress; everyone seeking an introduction, or information of any and every conceivable kind; and as if this were not enough, he is expected to supply with commendable regularity reports on the trade, manufactures, climate, ethics, and ethnology of the district which he serves. He must speak multifarious languages, and know enough of all the "ologies" to prevent him from making any mistakes. He must possess the patience of a donkey and the good temper of a cherub. As a diplomatist he must be above praise, and not only contented but willing to take his life in his hand, and even to lose it in a street riot. It is surely not remarkable that men who combine such a number of really great qualities should be scarce, or that now and again we find an individual who is just short of the normal standard of merit. But while we are prepared to admit all this, we cannot shut our eyes to the fact that the British Consul not unfrequently fails to understand the situation, and that he sends home advice which his readers will certainly not take, and would not be wise if they did. We have heard it said that the character of the advice is due to the nation of the man who tenders it, and that, being a foreigner, he fails to understand Englishmen. But this argument has small foundation in fact. The number of our Consuls who are not British is small, and we must seek elsewhere than in their nationality for the explanation of the advice. After all it is easily understood. When a Consul sees in his district a German who is carrying all before him, and selling goods as fast as he can take the order, he is naturally jealous, and writes home to urge on the English trader the necessity for a display of energy. The Consul forgets that the class of trade done by the German is one that the Englishman will not touch. It has already been said in our pages that it is as wise to recommend a West-end coachbuilder to take up the manufacture of costermongers' barrows as it is to urge on the English-

man the pushing of some of the branches of trade which our Consuls favour. There is, no doubt, manifest in their reports a lack of discrimination; and it is just this lack of discrimination that brings the Consul into disrepute. We have repeatedly heard it said that the English Consul has no competent knowledge of the true inwardness of English trade; and it is impossible to read some of the reports that we receive without perceiving there is some ground for the accusation.

Two considerations suggest themselves here. The first is that the British trader expects a great deal too much from the Consul; the second is that the Consul seems to think that so long as something is sold, no matter what, all goes well. Unfortunately the Briton abroad is exceedingly helpless—unless he has a sword in his hand—and the British trader expects the Consul to do for him, directly or indirectly, that which he ought to do for himself. It is possible, if not probable, that we should, after all, get on better than we do if we had no Consuls at all, but simply subordinate officials to conduct routine office work. The absence of the Consul would compel the British trader to rely more upon himself; better men would be selected as travellers and agents and representatives of English firms. If it was fully understood, for instance, that a man going to Russia, let us say, would have to trust solely to himself, care would be taken to send no one who could not speak French and Russian. The contention is so obvious that we need not push it further. Turning to the consular theory as stated above, we believe that its source is ignorance of the character of English trading as a whole. A competent knowledge of the characteristics of the trade of different nations would prevent the Consul from falling into errors. The subject is, of course, very much too large to be dealt with here as a whole, but we may direct attention to one or two things which claim notice. A characteristic of German trade is the production of very low-priced goods in large quantities, such as table forks at 3d. a dozen, table knives at 6d. a dozen, and so on; hundreds of other commodities might be mentioned, but these will suffice. Now it is quite useless for a Consul to mourn because English firms will not compete in such articles. In the first place, Sheffield could not make them at the price if she would, and she certainly would not if she could. The German is well satisfied to do a trade with peasants who take long credit for sums aggregating but a few pounds. The English trader will have nothing to do with trade of this kind. But unfortunately the Consul does not always understand this, and his reports are criticised. In the words of a City merchant, "As a matter of fact, the reports, as we get them at the present time, are practically useless. They are not up to date, neither do they contain the information that is required."

It is stated that the Foreign-office is to blame; but this statement must be taken with a grain of salt. We believe that a certain amount of agitation will do good, and that just as our merchants and manufacturers have had to learn a good deal—and that now

and again very unpalatable—from the Consul, so the Consul might learn a great deal from the merchant if he would try. Improvement all round is wanted, and might be effected with a little trouble. We venture to think that a debate in the House of Commons on the consular service would supply a great deal of much-needed information. It would no doubt dispel some illusions, and would serve to bring the Consul and the trader into touch with each other, to the mutual benefit of both parties.

TELEGRAPHS AND TELEPHONES IN PERSIA.

The first telegraph line in Persia was established about thirty-six years ago, and in the beginning was vigorously denounced and opposed by the priests as being a species of magic, and closely allied to other evil principles greatly subversive of religion and the best interests of the State, and as such not to be permitted to have a place in the economy of Government. This opposition, however, was overcome, and the class which resisted so stoutly at the first now use the telegraph with the greatest indifference. In the year 1862 the construction of a telegraph line from India to England through Persia, Russia, and Germany was commenced, and it began working on the 1st January, 1870. Some work had, however, been carried on for three or four years by a line through the Euphrates valley; but according to the United States Vice-Consul at Teheran, this was not by any means of a satisfactory character, and serious errors, delays, and interruptions occurred. This line is still used occasionally. The Indo-European is a well-constructed and efficiently managed line. From Bushire to Karachi there is both a cable and a land line. This line provides the local native administration with one wire which can always be depended upon. The local lines, with the exception of the one wire mentioned above, are the property of the Persian Government. The ownership was acquired by the cost of construction, and has been maintained by defraying the expenses of preservation. The actual administration is deputed to one man, who, until very recently, contributed to the Government £2,400 a year. This royalty has now been raised to £6,000 a year. The yearly receipts of the telegraphs have been about £12,000, and the expenditure equals, if not exceeds, the income. In consequence, certain reforms are to be initiated in the direction of compulsory payments. It is stated that fully 50 per cent. of the telegrams are sent free. Officials of the Government (central and local), priests, expounders of the law, relatives of persons connected with the working and the administration, and everyone who can provide himself with a reason or excuse, send their telegrams free of expense. As this system has been growing for many years past, and most of those who have benefited by it are in a position to give trouble, the management find it difficult to introduce changes necessary for their own

protection. The Persian local system comprises about 3,100 miles of wire and 86 offices for the receipt and despatch of messages. The wire provided by the Indo-European administrations, gratis, is about 1,300 miles long, and extends from the Persian Gulf to the Russian frontier. Stamps are not used for any purposes in Persia, except for letters. Messages are restricted to ten words, at a charge of $2\frac{1}{2}$ krans (about ninepence). The actual charge for the message is 2 krans, and the half kran is for the paper on which it is written. In case the message extends to a large number of words it is calculated at the rate of ten words to the two krans, and not $2\frac{1}{2}$ krans. This tariff is the same for any distance in Persia; there is only one charge. The Persian newspapers rarely contain information of sufficient importance to be sent by telegraph, consequently there is no Press rate, and, indeed, there are very few Press messages. There are four newspapers in Persia, printed in the vernacular, and under Government control. These should be issued once a fortnight, but they are often issued at longer intervals; they are in no sense considered as leaders or exponents of the ideas or feelings of the people. As regards telephones the late Nasredin Shah on the 8th December, 1889, granted to the then Minister for Foreign Affairs a concession for electric lighting, the introduction of telephones, phonographs, and the application of electricity to industrial purposes to the whole of Persia, with protection to the monopoly for the period of sixty years. This concession was transferred to an American citizen for a certain valuable consideration, but for want of means the purposes of the concession have not been put into execution. In order to protect the concession from lapsing, two or three wires were put up and kept in a workable state, and are now in use. Five years ago the railway and tramway company commenced erecting private wires for anyone who would undertake the expense, and they established an exchange office on their own premises at Teheran. It has not been extended to any other town. So far, no records have been kept of the number of miles of wire erected, but the Vice-Consul says that from his observation he should estimate it at about fifty miles—this is including the wires into villages of summer resort, and those to different parts of the city. At the present time there are fifteen owners of private wires, each of whom pays the company about 8s. 6d. per month for keeping the wires in repair, and the instruments in order. The receipts about balance the expenditure, but this only includes the free use of the lines by the company, who provide the only office there is in the city, and two in the country during the summer months. As messages are not received from the public, no tariff has been formulated. Subscribers are put into communication, and use the telephones as long as they wish. As a more extended use of the telephone would interfere with the receipts of the telegraphs, permission to use it has not been granted to distances appropriated by the telegraphs.

HUNGARIAN MINERAL WATERS.

In view of the extensive manufacture and sale of artificial mineral waters in Hungary, the Hungarian Minister of the Interior (as the supreme health authority) has, according to the United States Consul at Budapest, issued a new ordinance, according to which licenses to manufacture artificial mineral waters may be issued only to druggists or chemists holding diplomas. The erection of factories for such manufacture will be permitted only after expert examination. The local authorities are expected to care for the regular medical supervision of such factories. The names of domestic or foreign natural mineral waters may not be made use of. It is also forbidden to use the same bottles, jars, capsules, corks, stamps, or trade marks for artificial mineral waters as for natural mineral waters of similar composition, and the word "artificial" must be marked in large letters on all vessels containing artificial mineral water. The name of the manufacturer and the place of manufacture is to be plainly written on the label. These regulations are to be enforced by fines, and in case of repetition, by fine and imprisonment. Failure to observe the regulations may be punishable by the revocation of the manufacturer's license. It may be pointed out that mineral waters form one of the principal articles of export to the United States from Budapest, and the surrounding locality.

General Notes.

MODERN DRAINAGE CONSTRUCTION.—Mr. Louis Hanks, member of the Society of Arts, read a paper before the Sanitary Institute Congress on "Failures in Modern Drainage Construction, with suggestions for their remedy," which is printed in the *Building News* for September 30. Mr. Hanks deals with the question of renewal of drains. He writes:—"Finding himself now called upon to incur a further heavy expenditure for putting in an up-to-date drain, the householder might reasonably ask for some guarantee that his new drainage system would, at all events, be watertight and in sanitarily efficient order ten years hence. . . . Undoubtedly such a guarantee could be given with regard to almost any other constructive works, but not in the case of an underground drain or its connections as usually constructed. This points to the existence of some inherent weakness or defect in either the material or workmanship of the drain-pipe and its joints, and to the need of some more permanently reliable drainage conductor than any at present in use."

CORRECTION.—In Mr. J. W. North's letter in the *Journal* for Sept. 30, the following corrections should be made—p. 871, line 5 from bottom of page, for printing *read* painting; p. 872, line 1, for water-proofed *read* watermarked.

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FRIDAY, OCTOBER 21, 1898.

*All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.***Notices.****EXAMINATIONS, 1899.**

The dates fixed for the Society's Examinations in 1899 are Monday, March 13th, Tuesday, 14th, Wednesday, 15th, and Thursday, 16th.

The Programme of Examinations is now ready. Copies of the Programme, with full details, and an Appendix containing last year's questions and reports by the Examiners, can be had, price 3d., post free, on application to the Secretary, Sir Henry Trueman Wood, Society of Arts, Adelphi, W.C.

Proceedings of the Society.**CANTOR LECTURES.****SOME PRINCIPLES OF FORM-DESIGN IN APPLIED ART.**

BY HUGH STANNUS, F.R.I.B.A.*

Lecture II.—Delivered 21 February, 1898.

SYMMETRICALITY is the first of the group of Laws which govern the Conformation of Objects or the Attitude of Animals. The term is derived from two Greek words which signify the quality of being *measured-together*. Obviously, when the two Halves of an object are designed in such a manner that, in every respect—each detail of the one half may be “measured with” the corresponding detail of the other half—then the Object in itself is symmetrical in conformation. Examples of this are:—in Architecture, the Triumphal Arch and the Temple-portico—in Sculpture, the Osirid-pier and the archaistic Antinoüs-statue—in Typography, the ordinary capital-letters H, I, O, T—&c. Among Animals: each Quadruped, Bird, or Biped, is divisible by an imaginary vertical Plane passing axially

through the body, from front to back, or from head to tail. Each external detail, on what is called the “right” side of the animal, be it eye, ear, leg, nail, &c. may be *measured* with the corresponding eye, ear, leg, nail, &c. on what is called the “left” side of the animal; hence these Animals are said to be SYMMETRICAL in CONFORMATION. These animals, however, having Volition and Locomotory-power, are—constantly moving; and are SYMMETRICAL in ATTITUDE in only exceptional cases: Quadrupeds or Birds are never so, in attitude; and Man is only so when he stands at “Attention” in preliminary Military Drill. At other times the standing man rests first on one leg, and then changes to rest on the other; and this deviation, from the stiff Symmetricality of the Recruit at “attention”, is termed BALANCE (which will be treated-of later).

The DISTANCES, of the various details from the axial vertical Plane, are exactly the same on each side of it, for each pair of corresponding details; hence the form of one side-half is the exact reverse of that of the other side-half. In the process, of making a Drawing of a symmetrical object, the student:—(a) draws the one side-half—(b) makes a Tracing in soft pencil of that, with the vertical axial Line marked upon it—(c) turns-over the Tracing so that the axial-lines coincide—and (d) thus transfers the other side-half *in reverse* of the former—This is a quick method of making the two side-halves to be the exact reverse or reciprocal drawing of each other; and is an economy of draughtsmanship which is much practised in Pattern-design. The act of turning-over the Tracing has conduced to the name, “Trace and turn-over”, by which it is generally known in that branch of Decorative Art.

The ASSOCIATED IDEAS connected with Symmetricality are related to—its Prevalence in Nature—its necessity in Architecture—its expediency (*i.e.* not Casuality) in the careful arrangement of affairs in daily life—in NATURE, Animals could not progress, nor Plants grow without it. In ARCHITECTURE, Buildings could not settle down evenly on their foundations unless the Side-halves were equal—In DAILY LIFE, it is associated with carefulness and accuracy: the Judge, who sits stiffly in the centre of the bench, leaning to neither side, and symmetrically-attired, is an example.

The CHARACTER of the Object also governs the application of this Law. Symmetricality,

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as adding a certain degree of Dignity, is appropriate in objects of a "monumental" character which appear to require a pre-meditated treatment, *e.g.* the Monarch's Robes, the Senate-house, the Chancel-screen, the State-carriage, the Grand-piazza, the City-viaduct, &c.; but it is out of place in a Peasant's Shawl, a Country-cottage, a Field-hedge, a Coster's Barrow, a Village Green, or an Alpine Bridge; and the person, who builds the double-fronted cottage with central Portico, is unconsciously committing the vulgarity of aping his superiors. Better that he should recognise the truth of the dictum:—"the grand style to the great things, and the homely style to the small things". The Grand Style is an ambitious effort to compete with the great; and the Hindoo Artists avoid exact Symmetricality, from this feeling and their consequent desire to escape from the anger of the Gods, that would descend on their Ambition.

INCREASE OF SYMMETRICALITY is observed in Objects and Features which lie in horizontal surfaces. Divisibility by *one* Plane, accompanied by the exact identity in size and design of the corresponding details on each side, has been shewn to be characteristic of Conformation in the higher animals; but there are examples among the lower animals which are divisible by more than one Plane, *e.g.* the Star-fish, the Sea-Urchin, &c.; and in the Vegetable Kingdom, the greater number of Flowers which lie in horizontal planes are poly-symmetrical. It will be observed that of the flowers which have an erect attitude, many of them, *e.g.* the Papilionaceæ, have one vertical Axis; and the greater number of those whose face or general surface is horizontal, *e.g.* the Daisy, &c., are divisible by *many* vertical Planes, excepting some, *e.g.* the Cruciferae, which are divisible by *four* vertical Planes, and some, *e.g.* the Liliaceæ, which are divisible by only *three* vertical Planes.

The TERMS for the degrees of Increase in Symmetricality (*i.e.* in the number of Axial-planes or Axes) are adopted from the Greek numbers. Thus in fig. 5:—the shape **M** is divisible by only one Axis (*a*); and it is therefore termed Mono-symmetrical—the shape **D** is divisible by two Axes (*a*, and *b*); and it is termed Di-symmetrical—the shape **T** is divisible by three Axes (*a*, *e*, and *f*); and it is termed Tri-symmetrical—the shape **P** is divisible by four Axes (*a*, *b*, *c*, and *d*); and it is termed Tetra-symmetrical or more often Poly-symmetrical—(the student is advised to fold a Piece of paper, cut to each shape, with the

crease along each of the Axes shewn; and the various degrees of Symmetricality will be seen).

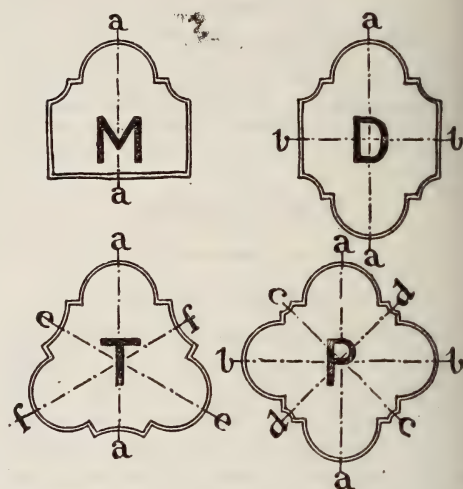


FIG. 5.

The APPLICATION of this LAW, to the Plan of the Capital in the three Classic orders of

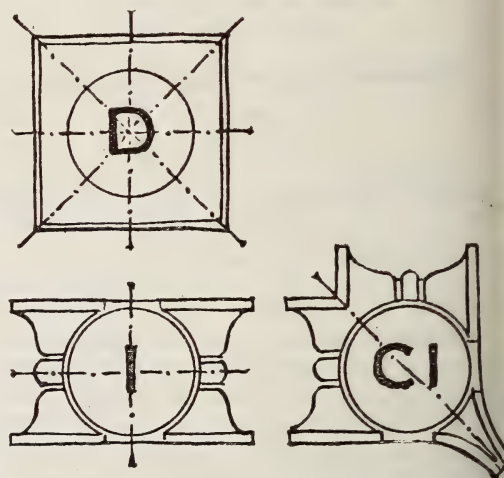


FIG. 6.

Architecture, is shewn in fig. 6 in which:—**D** shews the Doric capital—**I** shews the Ionic capital—**C I** shews the corner Ionic capital—

and **K** shews the Korinthian capital—The Doric and Korinthian capitals, it will be observed, are *tetra-symmetrical*; and therefore may be used, not only along the front and flank of a building, but, also at the corner where the front and flank meet. These two capitals have never been otherwise than “all-round” capitals; and no necessity for readjustment of their parts has ever arisen. The Ionic capital differs from them in being a “front and side” capital. In each capital—the two fronts shew Volutes carved in vertical planes; and hence they are termed the Volute-fronts of the capital; while the two sides shew the coiling-in of masses which are profiled, on the under surface, somewhat similarly to the double-bodied Baluster; and hence they are termed the Baluster-sides of the capital. The normal Ionic capital is only *di-symmetrical*. It can, therefore, be used along the front of a building which does not require columns at the flanks; but when it is applied along both front and flank, a difficulty is caused at the corner, owing to it being not *tetra-symmetrical*. An attempt to meet this difficulty was made in the Nike-apteros Shrine, and, later, in the Erechtheion, and other Temples, as shewn at **C I**. In these corner-capitals, the Baluster-sides respond to those of the normal capitals on the front and flank, and the Volutes in front of these sides also correspond to the Volutes of the normal capitals; but the outer Volute on each face is bent-out in plan, as shewn, making a large horn-like projection at each corner of the building, that is not pleasing; and the rear Volutes make a re-entrant Angle, abutting against each other in such a manner that one-half of each volute disappears behind the other; and the result is a hiatus. If the later architects had “harked-back” to the four-faced capitals of the Bassinaos, and had developed from that (in which the Volutes are *conjoined* and *integral*); then the solution of the difficulty would not have been left till the Temple of Saturn at Roma (in which the volutes are isolated and fortuitous). It must be regretted that, in the corner capital, the Greeks did not evince their usual æsthetic insight; and that the disasters of that insane Peloponnesian War prevented further artistic consideration of the problem. The Corner-capital, it will be seen, is *mono-symmetrical*; and that fact appears to have, hitherto, precluded a successful solution.

The APPLICATION, of this Law to OBJECTS, firstly depends on the Attitude, towards-the-

Horizon, of the surface on which or against which they are placed.

MONO-SYMMETRY has been observed in Nature to govern the form of objects that are *erect* in attitude. Hence Persistence-of-Memory or Association-of-Ideas may have led artists to design objects which were intended to be upright, whether in isolation or against a (vertical) wall, with only *one* Axis, and that in a *vertical* attitude. It may be further observed that, in objects connected with Walls and other vertical Architectural-features, the principle of SYMPATHY seems to suggest that the verticality of the Axis (*i.e.* of the Object) will better consort with the verticality of the wall-surface than if the Axis were in any other attitude.

POLY-SYMMETRY (or any degree more than *mono-symmetry*) has also been observed in Nature to govern the form of objects in a *horizontal* or quasi-horizontal attitude. Hence, again, the effect of Memory and of Association will lead to Poly-symmetricality in Ceilings and Floors. And further, be it observed that objects and features on horizontal surfaces (which are approached in various directions, and seen from many different points of view) will be less unsuitable in effect when the attitude is not strongly marked (because of the number of axes in different directions), then when it is conspicuous (because of its having only one Axis). In fig. 7, two

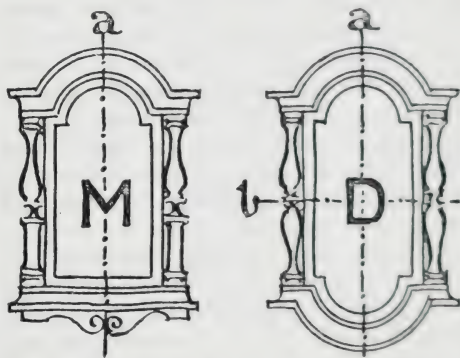


FIG. 7.

sketches, for a Mirror-frame, to be fixed against a Wall, are shewn:—**M** is *mono-symmetrical*, having only the one Axis (a)—**D** is *dy-symmetrical*, having the two Axes (a) and (b)—It will be observed, for the reasons above-given, that **M** is the more suitable for a Wall-feature; and **D** (without the balusters) would be more permissible as a Ceiling-feature; and from this example it may be deduced that *di-symmetry* militates against the sense of

verticality that should govern the application of objects on vertical (Wall) surfaces.

The AVOIDANCE of SECONDARY - SYMMETRICALITY in the wrong place, is also important. When, in the front of a building, there is a Side-entrance on each side of the Central entrance: then the amount of importance, to be given to their design, should be in accord with their subordinate or secondary position. And it is nearly always possible to arrange that the Secondary-axes, thereby created, shall not be in the centres of the Wings of the building. The Church-front in fig. 8, is that added

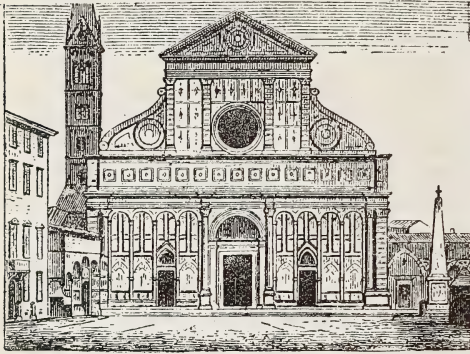


FIG. 8.

by Alberti to the older nave and aisles of Sta. Maria Novella, in Firenze. The Distances between the Doors were fixed by the axes of the nave and aisles; and were therefore part of the data of the problem. It will be observed that he has arranged the column at the flank of the central door and in immediate connection with it, and the similar column with a coupled pier at each end of the front, at such distances that the wing (or space between the columns) on each side is divided into four bays (which is an *even* number); and that the Side-door occupies the second bay from the Centre-door. Thus each side-door avoids being in the centre of the Wing. Had he—by reducing the width between the two columns that flank the central-door, and by increasing the breadth of the end-piers—arranged each Wing in *three* bays; and placed the side-entrance in the central bay of each—then the Secondary-axes would have been more important than the Primary-axis; and effect of the whole Front would have been spoiled. As it is, it is a fine example of scholarly design; and well worthy of admiration and study.

DISREGARD of this Avoidance is seen in the front of the National Gallery, Trafalgar-square, London, in which there is an *odd*

number (three) of windows in each division of the Wings; and, as a result, the eye, in travelling over the building, is perplexed at finding so many Central-axes or Axes-of-Symmetry attracting its attention. Had there been an *even* number of windows in each division, the effect would have been less distracting. Another interesting instance is seen in the front of the People's Palace for East London, in which there is one Primary Axis-of-Symmetry in the recessed Centre, and one secondary and two tertiary Axes in each projecting End-block, total seven axes.

The POSITION of a Feature also governs its treatment. When the feature is *axial* (*i.e.* central), then it should be treated in a symmetrical or quasi-symmetrical manner; and when the feature is *unaxial* (*i.e.* at the side), then symmetricality should be avoided. It will be observed that where there is an Axis of symmetry—there the eye rests, without seeking further; and where there is not symmetrical arrangement—there the eye does not rest but seeks for the centre of the composition. Hence the "east-window" of a church will be designed with an *odd* number of lights:—3, 5, 7, or 9; with a quasi-symmetrical figure in the painted glass of the centre-lights, and with an un-symmetrical figure, looking inwards, in each of the side-lights. And, to avoid symmetricality, the Side-windows will be designed with an *even* number of lights:—2, 4, or 6 (and the West-windows may be designed with even 8 or 10).

The AVOIDANCE of Symmetricality in the WRONG PLACE, is important. Some objects should have, by reason of the nature of their function, only one Axis-of-Symmetry. Places of Worship are in this category; and it is interesting to observe how careful the Greeks were to prevent even the appearance of symmetricality at a wrong place, *e.g.* in the flank of a Temple. The Entrance to the naos or opisthodomos, was always in the centre of the end, *i.e.* axial with the centre of the Pediment; hence the number of columns at the ends of temples (with two, or perhaps three, exceptions) was always an *even* number; and the eye intuitively seeks and finds, in the void (between the 2 columns nearest the centre), the Axis-of-Symmetry; and there is content to rest. But in the Flank of the temple there is (with one exception) no entrance, and no Axis-of-Symmetry; hence the avoidance of an *even* number of columns, so that the eye may not be drawn to a central void, and perplexed.

DISREGARD of this Avoidance is a blemish

in the external flank-elevations of the otherwise beautiful little church of St. Mary-le-Strand, in London, the southern flank of which is shewn in fig. 9. Here, it will be observed, the third

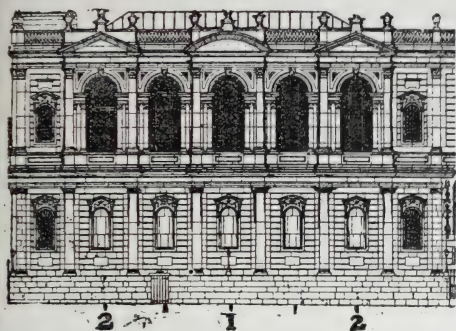


FIG. 9.

Nave-window is treated with columns, entablature, and segmental-pediment, and the first and fifth are treated with angular pediments; and all are thereby made into Axial-features. This treatment not only destroys the breadth of the composition, but it dignifies, as centres-of-symmetricality, three windows which should not be axial in any manner; and it thereby militates against the chief and only Axis of the church, *i.e.* from the Entrance-door to the Communion-table.

BALANCE is the second of the group of Laws which govern Conformation and Attitude. The term is derived from a Latin word which signifies the quality of being *weighed*, and of preserving the equilibrium of the Weighing-beam. Obviously, two objects or sets of objects may balance each other, and yet be very different in *form*. So, also, in Applied-art, the two portions of an object on each side of an imaginary vertical Line passing through its Centre-of-Gravity may have the same weight; and, although very different in form and apparent bulk, may yet balance each-other.

EXAMPLES are seen:—in Nature in every Forest-tree: they are not symmetrical; and without Balance they could not remain erect: There is, approximately, an *equal weight* of Branches in all directions, to enable the Tree to maintain its Equilibrium; and those trees which, by stress of the elements, have lost branches or lean-over on one side, show that they have lost equilibrium; and the trunk is in-strain—in the Animal Kingdom, every erect movement shows the effect of this Law, or otherwise the animal would fall to the ground—in external Architecture, most Dwelling-houses, if designed according to the Function of

each Room, will exhibit the effect of this Law, rather than that of Symmetricality—in Sculpture, almost every isolated statue (an extreme case, fig. 10, is seen in



FIG. 10.

the bronze equestrian statue of Peter the Great, at Petersburg in Russia, in which, by the expedient of varying the thickness of the metal, making it heavier in the hind-quarters of the horse and very light in the fore-quarters and the figure of the Man, and by making the hind-legs solid, and attaching them and the tail to the Serpent, the whole is partly balanced and partly tied-down)—in Typography, the ordinary capital-letters, B, D, G, M, N, Q, R, S, W, X, Z—in Mechanics, everyone, who has observed the machinery behind the Dial of a large Clock, will have seen the Counterpoise-weights fixed to the pinion in an opposite direction to the Hands, for the purpose of balancing their weight—&c.

The APPLICATION of this Law will be treated-of more fully in the Law of STABILITY, *q.v.*, and in that of Reciprocality, *seq.*

RECIPROCALITY is the third of the group of Laws which govern Conformation and Attitude. The term is derived from a Latin word which signifies the act of taking (a step) backwards and forwards. In Mechanics, all Motions which are repeated in alternately *opposite* directions, *e.g.* the Piston-stroke, the Beam-libration, the Pendulum-oscillation, &c. are termed Reciprocal. So, in Applied Art, one Object that has an Attitude the exact reverse of another, is said to be symmetrical to the other, *e.g.* the *Pair* of imitation Egyptian

Sphinxes that face each-other by the Obelisk on the Thames Embankment, in London—or the Couchant Spaniels, made in pottery, that are seen *in pairs* on the mantle-piece in rural cottages.

and each Feature, *e.g.* forehead, mouth, chin, of which the animal is endowed with only *one*, is *symmetrical*—in Architecture, examples have been given, but the front of the Cathedral at Lichfield may be adduced as a



FIG. 11.

In SEPARATE OBJECTS or Features, that are Pairs, *i.e.* the exact reverse of each-other, the term used is “RECIPROCITY”; but when the Pair are parts of the same Object, *i.e.* are equal reversed Halves of it, then the term used is “SYMMETRY”, and it is applied to the whole object. Thus an Ear, considered by itself, is un-symmetrical but is *reciprocal* to the other Ear; while the complete Head, including the pair of Ears, is *Symmetrical* (in the reversed identity of its two equal Halves). So also, in the Temple on Ægina, the acroter at one end of the pediment (fig. 11) is *reciprocal* to the one at the other end; while the whole Pediment, including all the Akroters, is said to be *symmetrical*.

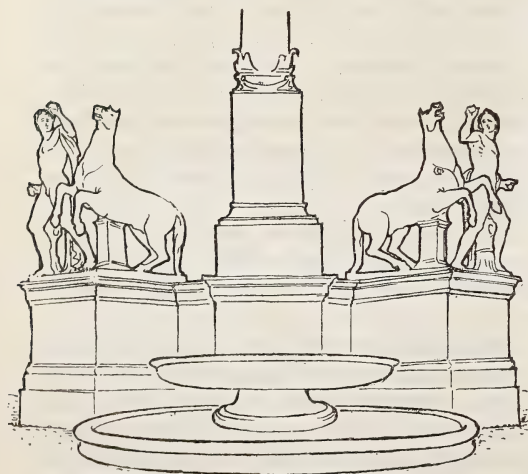


FIG. 12.

EXAMPLES are seen:—in Nature, each Feature, *e.g.* ear, nostril, arm, hand, leg, foot, of which the animal is endowed with a *pair*, is un-symmetrical in itself but is *reciprocal* to the other corresponding Feature;

very artistic example, the bulk of the two towers being increased on each outer side, and thus not only avoiding a Secondary-axis but

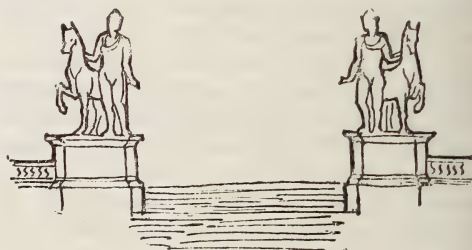


FIG. 13.

making the two towers Reciprocal—in Sculpture, the figure and horses on the Quirinale, at Rome (fig. 12), also those in the Capitolino (fig. 13), the figures of the Tartarughe Foun-



FIG. 14.

tain, also situated at Rome (fig. 14), of which one pair of figures was modelled, and two casts in bronze of each figure, making four in

all, were arranged alternately, as shewn. The figures of the Korai, of the Pandroseion at Athens, are another instance of

dom. Most Tympanum-sculpture is arranged in a quasi-reciprocal manner; and the pairs of recumbent figures, that were fashionable



FIG. 15.

this law, the three on the eastern-half being represented as resting on the *left* leg, and the three on the western-half on the *right* leg.

ABUSES sometimes result from applying this law too severely. An example may be seen in the Untersachsenhausen at Koeln, where, in a pair of Cyclops supporting a projecting Bay, one of them is *left-handed* in order to be strictly reciprocal. Some of the shields, in one of the chapels at Rimini, are provided with the Bouche on the sinister side, as if for left-handed persons, for the same reason.

A FREE TREATMENT, which is also more sensible, is shown in the figures on the tombs in S. Lorenzo, at Firenze, by Michelagnolo (fig. 15), in which, while the architectural features are strictly reciprocal, the sculptural figures are only reciprocal in mass-form, *i.e.* *quasi-reciprocal*. The group of Karl der Grosse (fig. 16) is also free; but the men that hold the bridle are "out-of-step" as a concession to reciprocity, that was not required. The groups of Virgins, at the ends of the Tympanum in fig 17, are quasi-reciprocal; and gain much from the free-

on pediments after Michelagnolo had set



FIG. 16.

the example, afford numerous examples of this free treatment.



FIG. 17.

Miscellaneous.

INDIAN COAL SUPPLIES.

Although Indian coal has not, so far, been a conspicuous success, it has, nevertheless, made sufficient progress to render English coal a constantly diminishing factor in the railway supply and other Indian channels of consumption. The output of Indian coal last year reached 4,063,000 tons, that of the previous year being 3,848,000 tons. Expressed in one way, the output has almost doubled since 1890; expressed in another, it has only increased by 2,000,000 tons during that period. The quantity of coal used by Indian railways in 1897 was 1,371,000 tons, of which only 47,000 tons came from England. In addition to the coal, about 358,000 tons of wood was consumed. Some interesting details have been published in the Administration Report on "The Railway in India," regarding the consumption, cost, and the collieries supplying Indian coal to the railways, which form the basis of the following article. The coal used on these railways is gradually increasing in amount, and in 1897 was 7 per cent. larger than in the previous year. The consumption of Indian coal increased by 12·8 per cent., and that of English coal decreased by 55 per cent.

The coal used varies very much in quality, and in considering the amount used, and the cost, this variation must be taken into account. The standard taken is Giridih (Kurhurbaree) best steam coal, and the equivalents which have been generally employed for converting the various descriptions of fuel into terms of Bengal coal are as follows, 1 ton of Giridih coal being taken as the standard :—

Description.	Equivalents.
Giridih (Kurhurbaree) best steam coal	1'00
Kurhurbaree (E. I. Railway) selected large coal	0'90
Welsh best steam coal	0'80
Patent fuel	0'70
Singareni coal	1'05
Bengal or Barakar steam coal	1'10
Umaria coal... ..	1'25
Mohpāni coal	1'50
Warora coal... ..	1'80
Wood fuel	2'50

These factors have been arrived at from a careful examination and comparison of the results of trials carried out within recent years on several railways, and are believed to represent the relative values of the different fuels as nearly as possible. The following statement shows the chief kind of coal used, and the prices* paid by some of the principal railways :—

East Indian Railway.—Kurhurbaree coal, delivered into waggons at Giridih, 3s. 9d. per ton.

Bengal Nagpur.—Bengal steam coal (38,000 tons) at 5s. 2d., delivered into waggons at Radhangar and

Dhudka by the Bengal Coal Company and the New Beerbhoom Coal Company respectively.

Indian Midland.

	Quantity used.	Price.	
	Tons.	s. d.	
Bengal coal...	10,437	5 1	f.o.b. Giridih.
Umaria coal...	42,000	7 6	At pit's mouth.

Bengal coal is being substituted for Umaria.

North-Western State Railways.

	Quantity used.	Price.	
	Tons.	s. d.	
Bengal	66,000	28 5	f.o.b. Kiamari, by Barakar Coal Compy.
Dandot	61,000	18 9	f.o.b. Kalapani
English	6,600	38 1	Delivered by Messrs. Forbes & Co. into waggons at Kiamari.
Khost patent fuel	2,211	15 0	f.o.b. Quetta.

Great Indian Peninsula.

	Quantity used.	Price.	
	Tons.	s. d.	
English	7,553	31 10	Intoboats at Bombay.
Bengal sea-borne	31,461	24 9	" "
Japanese	6,121	25 11	" "
Singareni unscreened	87,248	7 6	f.o.b. Yellandu.
Warora... ..	55,449	8 5	At pit's mouth.
Umaria, large	15,429	7 6	f.o.b. Umaria.

Bombay, Baroda, and Central.

	Quantity used.	Price.	
	Tons.	s. d.	
English	22,477	45 11	Intoboats at Bombay.
Bengal	28,853	24 9	" "
Singareni	25,222	22 0	f.o.b. at Dadar Junct.

The principal descriptions of English coal used were Nixon's Navigation, Ferndale, Powell Duffryn, and Davison's best Hartley.

The above figures, while omitting some of the principal railways, include those which are the largest buyers of English coal, and the prices which we have given enable one to judge of the differences in price between English and Indian coal. So great is this difference that it is more than remarkable that English coal has not been superseded a long time ago. We now proceed to give some account of the collieries which chiefly supply the Indian railways, their outputs, and the quantity of coal raised per person employed. This latter figure is in some cases so ridiculously small that it almost seems as if there were some error in its calculation.

* Throughout this article the rupee has been converted at 1s. 10½d.

Kurhurbaree and Serampore Collieries.—These are worked in connection with the East Indian Railway, and the entire supply of fuel for that railway is drawn from them. These pits mined 454,000 tons of coal in 1897, and employed 6,113 persons. 363,000 tons of large coal were produced, and 52,000 tons of slack coal, from which 18,200 tons of coke were manufactured. The number of tons raised per person employed were 74, as against 81 tons in 1896. The cost on the net output was 3s. 9d. Since last year an air compressor, piping, and a Stanley heading machine have been erected, and the briquette plant at Serampore has been completed, and now turns out 90 tons of briquettes per day by the lime-meal process.

Makum Collieries.—The Assam Railways and Trading Company work three collieries, viz., Ledo Valley (with two mines), Upper Ledo and Tikak. The working of those at Namdang and Tirap has only been recently commenced, and they are not yet fully developed. The output of coal during 1897 was 184,271 tons, against 176,436 tons in the previous year. The Assam coal is generally small and soft, but its softness has not proved a drawback to its general use for all purposes. It has a very small per-centage of ash, and gives a very clear bright flame, with great local heat. The demand for Assam coal is increasing, and it is largely used by ocean and inland steamers, railways, mills and factories.

Warora Colliery.—This colliery, worked by the Government, has seven shafts, for pumping, winding, and ventilating, of which the deepest is 245 feet, the shallowest 102 feet. It mined, in 1897, 111,654 tons of coal, and employed 821 persons, the number of tons raised per person employed being 136, as against 156 tons in the previous year. Two thousand one hundred tons of fireclay were raised for brick and tile manufacture. The Great Indian Peninsula Railway was supplied with 56,000 tons during the year. Other customers were the Empress Mill, Nagpur, the Hinganghat Mill Company, the Berar Manufacturing Company, and the general public. The price per ton at the pit mouth of the coal sold to the Great Indian Peninsula Railway was 8s. 5d., and the average selling price at the colliery for all coal 8s. 4d.

Mohpini Colliery.—This mine is worked by the Nerbudda Coal and Iron Company, Limited. The output in 1897 was 19,975 tons; 687 persons were employed, and the number of tons raised per person employed was 29. The output of the year was disposed of as follows:—Sold to railways, 15,713 tons; sold to mills, presses, &c., 1,532 tons; colliery consumption, 2,753 tons. The colliery consumption thus works out at about 13 per cent. of the total output.

Umaria Colliery.—This colliery, worked by the Government, produced 124,000 tons of coal in 1897, employed 2,617 persons, and had an average output per person employed of 47 tons, as against 68 in the previous year. The mine was worked at a loss due to a restriction of the output, and the increase in the

rate for cutting and raising coal, owing to the working places being at a greater distance from the pit's mouth. The chief customers are the Indian Midland Railway, the Great Indian Peninsula Railway, the Bengal-Nagpur Railway, and the general public. The coal consumed at the colliery figures out at about 9 per cent. of the total output.

Coalfields at Telanpali, near the Eeb River.—The diamond-drill boring in the vicinity of the Eeb bridge was carried out during the year to a depth of 485 feet, and samples of the cores sent to the Director, Geological Survey, on whose report the boring was directed to be continued to a depth of 600 feet, unless crystalline rocks were struck at a lesser depth.

Singareni Colliery.—These pits are worked by the Hyderabad Deccan Company, Limited, and produced 365,000 tons of coal in 1897 by the employment of 6,455 persons. The output per person employed is thus 57 tons, as against 45 tons in 1896.

Dandot Colliery.—This mine is worked in connection with the North-Western State Railway. There is only one seam of coal, and it lies at an elevation of about 2,000 feet above sea level in the Salt Range. The output of coal in 1897 was 79,647 tons, 1,997 persons being employed. The output per person employed was 40 tons, as against 36 tons in the previous year. The colliery is worked chiefly for the supply of steam coal to the locomotive department of the railway, but a fairly regular market is also obtained for slack coal, which is used by the public for brick burning and various other purposes.

Bhaghanwala Colliery.—This colliery is also worked in connection with the North-Western State Railway. It is situated in the Salt Range, about 1,800 feet above sea level, and about 20 miles east of Dandot Colliery. The seam of coal is the same as that at Dandot, but is here thicker and not of such good quality. Coal has been extracted during the year from one mine or district only, where the seam is tilted up at an angle of 40° to 50° from the horizontal. This disturbance of the strata has rendered the coal very soft and friable, and the per-centage of slack is heavy. The nature of the coal also renders it very liable to spontaneous combustion. The total output was only 13,100 tons; 334 persons were employed, and the average output per person was 39 tons. The colliery consumption was only 4·5 per cent. of the total output.

Khost Colliery.—The production was 8,788 tons; 217 persons were employed, and 40 tons were raised per person employed. The greater part of the output is used by the North-Western State Railway, in connection with which the colliery is worked. Pressed-fuel manufacture is undertaken here, 2,199 tons being made in 1897.

The sales for the year were made principally to the Great Indian Peninsula Railway, East Coast State Railway, Madras Railway, Southern Mahratta Railway, South India Railway, Bombay, Baroda, and Central India Railway, Nizam's Guaranteed State Railway, and Bombay Mills. The opening

out of the workings of this mine is being pushed on with all speed, and, in order to facilitate the progress of the main winning levels, two of Jeffrey's compressed-air chain coal-cutting machines, with air rotary coal drills, have been put to work.

A large air-compressing plant has been erected at the Batten Pit to provide power for the underground machinery. Unscreened Singareni coal was the only coal sold during the year.

The proportions of this coal are :—Steam coal, 72 per cent. ; nuts, 19 per cent. ; slack, 9 per cent.

Sharigh Colliery.—This mine was closed in May, 1896, and no coal has since been raised.

Baluchistan Coal Mines.—The chief areas within which, during the past year, coal mining operations have been carried on are those in the Harnái Valley, the Sor Range, the mines near Mach, and in the Digari district.

The collieries in the Harnái Valley, viz., Khost and Sharigh, worked by the North-Western State Railway, have already been referred to. There are five owners, who, under concessions, carry on operations in the remaining mines. The octroi receipts for coal passing into the station of Quetta show that about 3,000 tons have paid dues this year, against 3,600 tons in the previous year. The greater part of this was sold to the Commissariat Department and private individuals in the form of patent fuel.

Letkonbin Colliery.—This colliery is worked by the Burmah Coal Company, Limited ; the output during 1897 was only 10,160 tons, as compared with 22,980 tons in the previous year.

The decrease of 12,822 tons in the total output was chiefly due to flooding of the mines. New workings have been commenced at a distance of about a mile from the old workings, where coal is of a superior quality.

Palana Coal Mine.—Coal has been discovered in Palana, a small village in Bickaneer territory, within the jurisdiction of the Saddar Tehsil, and a search party is at work. There are also indications of coal in other places, and endeavours are being made to locate the coalfield, and to find the most advantageous place to start on. At present work is confined to the shaft.—*Iron and Coal Trades Review.*

ELECTRIC LIGHTING IN BRUSSELS.

On July 22nd last the first trial of the complete installation for illuminating purposes in the Gare du Midi in Brussels was made, and pronounced thoroughly satisfactory, and the company which performed this work has received a contract from the Government for similar installation in the Gare du Midi of Ghent. When the city authorities of Brussels, a few years ago, proposed the question of lighting public places, such as railway stations, parks, &c., by electricity, and of supplying electricity to subscribers the same as gas, a great cry was raised and protestations made against the innovation, urging that it

would ruin the gas works and injuriously affect the communal exchequer. Recent statistics show that during the past year not only has the use of electricity increased, but that the profit from the sale of gas is considerably in excess of that of previous years. Deducting the amount expended for establishing plant, &c., the city derived a profit of £8,896. The most important installation recently made in Brussels is in the king's palace. When the work is finally completed there will be 7,500 lamps, of which a large number will be of 5-candle power, employed in the chandeliers illuminating the ball and reception rooms. There are, according to the United States Consul at Brussels, about 47,391 lamps reduced in units of 16 candles, in the city system, averaging 117 lamps per 100 running meters of canalised streets. This number includes 770 arc lamps and 28 electric motors, the latter varying from one-tenth to 10 horse-power with a total of 105 horse-power. In view of the increasing use of electricity in Belgium, the Consul is of opinion that there is an excellent opportunity for the introduction of electric apparatus of all kinds.

ECONOMIC CONDITIONS OF SIBERIA.

Until very recently Siberia, so long unknown, had an entirely artificial existence. The Russians themselves were almost as ignorant of its resources as the outside world, and regarded it merely as a country of transit ; they knew that goods from the Far East, especially teas, passed through it, meeting on the way some few European products, and, above all, long trains of convicts and exiles. The work on the great Trans-Siberian Railway has been the first cause of the economic development of the country. Hitherto Siberia has been inhabited only along the caravan route ; a few miles on either side, not the slightest trace of settlements or of cultivation could be found. The caravan route extends from Mongolia to the Ural, with branch roads to the Amur, Lena, and Altai. This road, like almost all others in Russia, has existed for centuries, but it is only a few years ago that the Government thought of keeping it in repair. Since then, villages have sprung up along the route, partly due to individual and partly to Government initiative. The railway doubtless has affected this business of overland transport, but it is far from having injured it fatally, as the long files of waggons and sleighs loaded with merchandise passing parallel to the iron road sufficiently attest. According to a report in the *Bulletin de la Société de Géographie Commerciale*, there are two reasons for this—the high tariff of the railway, together with its still primitive organisation, and the necessity for the peasants to find employment for their horses, especially during the long winter months. The rivers afford the least expensive means of transportation since boats have been forced by competition to lower their tariff. Unfortunately, the great Siberian rivers (except the

Amur) flow from south to north. It has been proposed to unite them laterally by means of canals. The canal from the Ob to the Yenisei, not yet completed, follows the Kiète, a tributary of the Ob, for about 310 miles, then crosses a great lake and, by means of a cut nearly five miles in length, joins a tributary of the Yenisei. This last river is reached about 155 miles north of Yenisséisk. When the innumerable rapids of the River Angara have been made navigable, the journey from Oust Kiakhta, on the Mongolian frontier, to Tiouimen, at the foot of the Ural, a distance of 3,604 miles, will be made by way of the Selenga, the largest tributary of Lake Baikal, the lake itself, the Angara river, which unites the lake with the Yenisei, the Ob Canal, the Ob river, and lastly the River Irtych. The third means of transportation is the railway. It was not projected for the development of Siberia, but to seek on the Chinese coast a port free from ice, which nature has refused to the Baltic Sea. The railway is actually finished as far as Tomsk. The first express left St. Petersburg on April 1, 1898, composed of eight carriages (sleeping, drawing-room, and dining carriages) lighted by electricity and heated by steam. Two trains a month are expected to make the distance, 1,939 miles, in six days. Singularly enough, this railway which was not considered a commercial enterprise has proved of great benefit to trade. Except troops and criminals, it was feared that there would be few passengers; the truth is that the number of trains might be doubled or trebled, as thousands of tons of merchandise are waiting for transportation. The road to Krasnoiarsk, the easiest of construction, is the most useful from a commercial point of view. In consequence of the development of traffic, the Russian Government has established a Custom-house at Irkutsk, through which the teas and silks from the Far East must pass. Cereals grow abundantly in Siberia, and this trade is in the hands of the English and is carried on chiefly by the great rivers and the Arctic ocean. Russia protects herself against Siberian grain by heavy railroad rates. Frozen meat is sent to St. Petersburg, wools, tallow, butter, sheepskins, leather, and furs are also exported. Valuable furs, however, are not found in the neighbourhood of the railway. The distilling industry is chiefly carried on in the Irkutsk Government, in the Yenisséisk and in Transbaikalia. Of twenty-one distilleries in Western Siberia, nine are in the Tobolsk Government, eleven in that of Tomsk, and one in the territory of Semipalatonsk. In Eastern Siberia there are twenty-two distilleries, and in the littoral district but one. Beer and mead brewing is carried on, and the principal breweries are located in Tomsk, Yenisséisk, Tobolsk, Irkutsk, and Akmolinsk. The total output is estimated to average about 1,200,000 gallons of beer, and 240,000 gallons of mead. Tobacco culture, although universally introduced wherever climatic conditions permit, possess no com-

mercial importance. The sugar industry is a perfectly new enterprise in Siberia, and the first beet sugar factory was opened in 1890 in the Minonsinsk district of the Yenisséisk Government. The manufacture of matches is growing from year to year, and the principal factories are in Tobolsk, Tomsk, and Irkutsk. On the whole, the manufacturing industries of Siberia are at present in an embryonic state. Different industries arise and develop merely for the satisfaction of local requirements, in consequence of which the business of industrial and commercial undertakings of Siberia is yet extremely limited. The mineral productions include salt, gold, iron ore, coal, and plumbago. Copper and other minerals are mined on a very small scale. Iron and coal are found everywhere; gold is also so universal that it might be called a Siberian specialty. In the basin of the Lena, and in all of the north-eastern portion of Siberia, there are said to be beds so rich that they might rival those of Alaska. Salt is unequally distributed, but it abounds in Western Siberia. In the district of Akmolinsk, on an average, seven or eight out of every ten borings yield salt water. The provinces of the Amur and of the sea coast are considered by Russia of great importance. They have been colonised officially at great expense, and for a long time all foreigners, unless naturalised, were forbidden the acquisition of land. Recently these regulations have been changed; the colony is thrown open and the influx of foreign capital is encouraged. All the Trans-Baikal region and the basins of the Amur and Lena are free from duty. Sugar, tobacco, wine, and alcohol alone pay duty at Vladivostok or Nicolaevsk. It is expected that for many years Siberia will offer an immense outlet for all kinds of machinery, and special attention might be paid to mining machinery and agricultural machinery and implements. Until lately there were no agricultural machines in Siberia. Siberia also offers a market for wool-working and match-making machinery, paper machinery, and brewers' and sugar machinery.

THE MEAT PRODUCTS OF URUGUAY.

The principal meat product of Uruguay is *tassajo*, or jerked beef. This article is exported to Brazil, Cuba, and some of the other West India Islands, and constitutes the principal article of food—so far as meat is concerned—in the former, and is important in the latter countries. The United States Consul at Montevideo says that the process of curing is as follows. After the animal is slaughtered, the entire carcass is cut into four pieces, the bones taken out in an expert manner, and each quarter cut in such a way that it forms a large slab. This slab of meat is hung on a rack, exposed to the open air, to cool. After about half an hour the meat is put into strong brine and kept there for about a half an hour, the blood being drawn out by this time. These slabs are then piled one upon another, and between each layer a

considerable quantity of salt is placed. It remains in this pile sufficiently long to give the salt a good opportunity of penetrating all parts of the meat. After this the slabs are put on racks again and exposed to the sun and air, and from time to time turned so as to expose all parts equally, until it is in this manner sufficiently cured. The meat is then piled up in large stacks and there kept for days, and piled over again from time to time until it is ready to be shipped. It is then put into burlap coverings, in bundles of about 100 kilogrammes (220 lbs.) more or less, and placed upon the foreign markets in this shape. The nourishing properties of this class of meat, according to chemical investigation, are stated to be 50 per cent. of its original state when fresh, 50 per cent. of its nourishing qualities being lost by the process it has undergone—the extraction of albumen by salt, &c. The number of cattle slaughtered for the production of *tassafo* during the year amounts to about 870,000 head in the entire republic of Uruguay, of which about 400,000 are slaughtered at Montevideo. Next in importance in the way of quantities of cattle used for export products is the Liebig meat extract manufactory at Fray Bentos. The yearly slaughtering for the production of this article amounts to something over 200,000 head. Consul Schramm says that, taking into consideration that 100 lbs. of good solid meat yield only $2\frac{1}{4}$ lbs. of extract, the immense loss of alimentary substance to the world may be imagined, and therefore from a standpoint of national economy, as well as food, the production of meat extract must be considered as a great waste of alimentary matter. No doubt this fact has given rise to the various and extensive experiments made in the field of chemistry everywhere, as well as in the great meat-producing country Uruguay, and has led to the discovery made by the Uruguayan chemist, Dr. Valdes Garcia, of the so-called *carne liquida*, in which he endeavours to combine the qualities of the extract of meat with the nourishing properties of the meat itself. This is the third on the list of the meat products of the country. Up to the present the process of manufacture of this liquid meat is the sole secret of Dr. Valdes Garcia, and he takes care to guard it; but it is supposed, that with the greater demand and the extension of the output, the process of manufacture will soon become common property. It is hardly to be presumed, however, that other countries which have not such great facilities for the raising of cheap cattle will ever be serious competitors in the production of valuable extracts of meat with Uruguay, where the cheapness of the raw and original material is the principal factor and ingredient of the fabrication. Fourth and last on the list of meat products of this country are the preserved meats, shipped to foreign lands, consisting principally of canned tongues of the cattle slaughtered, mutton, and some few other kinds of canned meats. The amount of such canned tongues exported during the year is about 2,500,000 lbs., and the amount of other meats only 12,000 lbs. A very large amount of tallow is also exported.

General Notes.

BULGARIAN LITHOGRAPHIC STONE.—H.M. Agent and Consul-General at Sofia reports in a despatch to the Foreign-office that lithographic stone, said to be of excellent quality, has been discovered at Negoshevo, in the Balkans, not far from Sofia. Messrs. Popoff and Company, the concessionaires of the quarry, not having sufficient capital to work it to advantage, especially the lower strata, where the best quality is found, are in negotiation with a German company, and hope, when funds have been provided, to produce annually about 300 wagon loads of the stone.

FLOWER-GROWING IN ENGLAND.—Mr. William E. Bear has contributed two articles on "Flower and Fruit Farming in England" to the "Journal of the Royal Agricultural Society," and the result of his investigations in respect to the first of these two classes is "that flower-growing is greatly extending in this country, and that the competition among home growers is becoming more and more severe. Foreign supplies of flowers have increased, but not nearly as greatly in proportion as home supplies, and it seems clear that home growers have gained ground in relation to their foreign rivals, except with respect to flowers for the growth of which foreigners have extraordinary advantages. . . . Whether the production of flowers as a whole is gaining ground upon the consumption or not it is difficult to determine. It is true that the prices of flowers have fallen generally, as those of nearly all other commodities have, but production, at any rate, under glass has been cheapened, and if a fair profit can be obtained, the fall in prices, without which the existing consumption of flowers would be impossible, does not necessarily imply over production."

DUTCH CHEESES.—A despatch, dated 12th August last, has been received at the Foreign-office from H.M. Minister at the Hague, transmitting *précis* of a published report. A meeting has been held at the Chamber of Commerce, at Leiden, to consider the causes of the decrease in the export of Dutch cheeses to England, and in the report of this meeting the following reasons are given for this decrease. It is attributed (1) to severe competition on the part of Canada, arising from advantages owing to low prices of cattle in that country, cheap rate of land, less taxation, and cheaper wood, and so less expense for packing purposes; (2) to the fact that an inferior article is put into the English markets passing for Edam cheese, and of the same form and colour, but made from skimmed milk; (3) to the preference of the British public for cheeses of the taste and shape of cheddar: the London shopman also prefers to buy the latter kind inasmuch as once cut there is a less tendency for the remainder to dry up quickly; (4) to the high prices which Dutch cheese obtains in France, Germany, and the Netherland colonies, which operate as a reason for improvements not having been adopted to regain a lost market.

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All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.

SWINEY PRIZE.

The Council have to give notice that the next award of the Swiney prize will be in January next, the fifty-fifth anniversary of the testator's death. Dr. Swiney died in 1844, and in his will he left the sum of £5,000 Consols to the Society of Arts, for the purpose of presenting a prize, every fifth anniversary of the testator's death, to the author of the best published work on Jurisprudence. The prize is a cup, value £100, and money to the same amount; the award is made jointly by the Society of Arts and the College of Physicians. The cup now given is made after a design specially prepared in 1849 for the first award, by D. MacLise, R.A. Any person desiring to submit a work in competition, or to recommend any work for the consideration of the judges, should do so by letter, addressed to the Secretary of the Society.

The following is the list of recipients :—

- 1849. J. A. Paris, M.D., and J. Fonblanque, for their work, "Medical Jurisprudence."
- 1854. Leone Levi, for his work on "The Commercial Law of the World."
- 1859. Dr. Alfred Swayne Taylor, F.R.S., for his work on "Medical Jurisprudence."
- 1864. Henry Sumner Maine (afterwards K.C.B.), D.C.L., Member of the Legislative Council of India, for his work on "Ancient Law."
- 1869. William Augustus Guy, M.D., for his "Principles of Forensic Medicine."
- 1874. The Right Hon. Sir Robert Joseph Phillimore, D.C.L., for his "Commentaries on International Law."
- 1879. Dr. Norman Chevers, for his "Manual of Medical Jurisprudence of India."
- 1884. Sheldon Amos, M.A., for his work, "A Systematic View of the Science of Jurisprudence."
- 1889. Dr. Charles Meymott Tidy, F.C.S., for his work, "Legal Medicine."
- 1894. Thomas Erskine Holland, D.C.L., for his work, "The Elements of Jurisprudence."

Proceedings of the Society.

CANTOR LECTURES.

SOME PRINCIPLES OF FORM-DESIGN
IN APPLIED ART.

BY HUGH STANNUS, F.R.I.B.A.*

Lecture III.—Delivered 28 February, 1898.

MATERIALITY is the Law which prescribes that the Forms of objects shall be such as will best suit the Materials of which they are intended to be made. Each Material has its own special qualities—its capabilities and its limitations—and these should be compared and considered by the artist in every design, so that he may glorify his material; not treating it as if he wished he had some other material to work-with, but making the most of the possibilities that he possesses. Materials should be worked in the manner that appears to be required by their characteristic qualities—*i.e.* in the manner in which it is easiest to produce the best effect or result, or as a Craftsman in each material would bound his efforts in each by the *Technical limitations* of each; and, though occasionally some work may be produced, for an Exhibition, by a clever craftsman, which may violate all considerations of the characteristics of the material—yet the Observer perceives that the principal and chief intention may be (though not admitted)—to produce a "*tour de force*" which shall surprise the ignorant and advertise the Craftsman—rather than the Artist's desire to make one more beautiful object in the world; and he will assess its value accordingly. The writer who pleads for sobriety in Technic may be sneered-at by the ambitious Craftsman, who may further assert that he *has used* his Material in a certain manner; and therefore he has demonstrated the possibility of thus working; but he may be reminded that, while all things may be lawful, some are not expedient, and that, just as there is only "one step from the sublime to the ridiculous", so Vulgarity ever dogs the steps of the ambitious Self-seeker.

The CHARACTERISTIC QUALITIES of each individual material must be studied. Detail which is suitable to *all* Materials *equally*, is thereby unsuitable (in the highest and most

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artistic degree) to *any particular* one. Without pretending to give an exhaustive list, some of the more prominent qualities may be antithetically arranged, *e.g.*—Largeness *v* Smallness, of available pieces of the material—Tenacity *v* Brittleness, in the consistency of the material—Ductility *v* Rigidity, in the elasticity of the Molecular-arrangement—Fibrosity *v* Crystallarity, in the texture—Hardness *v* Softness, in the surface—Fineness *v* Coarseness, in the cohesion of the particles—and Opacity *v* Translucency, in the diascopic quality of the material.

LARGENESS *v* SMALLNESS, of the *available-size* of the material, governs the design of *stone Walls*; and the eye becomes accustomed to assess the bulk or thickness of the wall from observing the height of the courses.



FIG. 18.

So, also, in *brick Walls*, with their String-courses and Cornices: the dimensions of the Brick ($2\frac{3}{4}$ ins., by $4\frac{3}{8}$ ins., by $8\frac{7}{8}$ ins.) govern the

masses of the design to a great extent. Also, in *wooden Doors, Shutters, &c.*: the breadth of the Deal-board governs the width between the Framing-styles.

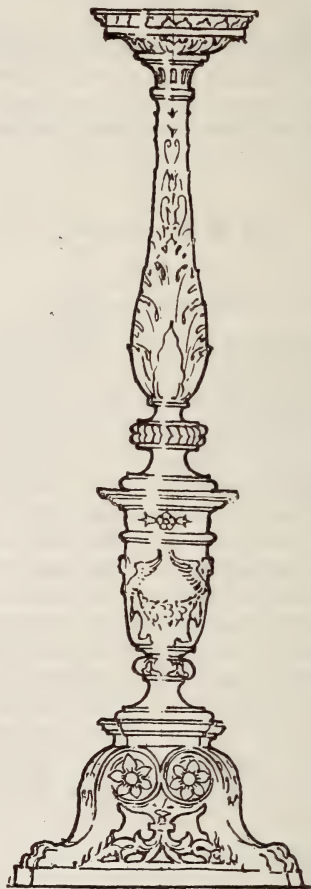


FIG. 19.

TENACITY *v* BRITTLINESS, in the *consistency* of the material, governs the design of all *isolated* objects.—In Sculpture: the difference in the pose of the Statue, between bronze and marble is great. The Bronze-metal has great Strength and Tenacity; and poses are practicable in this material which are quite unsuitable to the more brittle Marble. In marble, there is no Equestrian-statue without a Tree-stump or similar adjunct under the Horse-body, *e.g.* in the Borghese Centaur; while in bronze, the Horse of fig. 16 (p. 903) is supported on the legs only, and the Horse of fig. 10 (p. 901) is wholly supported by the two hind-legs. There is no marble statue with an unsupported outstretched Arm that is not fractured, *e.g.* in the Apoxyomenos (*i.e.* the Athlete who is scraping his arm with a Strigil); while the

arm of Cellini's bronze Perseus is uninjured ; and other instances might be added. The Adjuncts, which often tax the imagination and power of the artist, are :—Tree-stumps, Drapery, Animals, Altars, Blocks indeterminate, &c. ; and the problem, when introduced, is how to "conceal the art", *i.e.* to endow them with some relation to the Storiatio of the Figure or Group, *e.g.* the Tree in the Apollo Sauroctonos, the Drapery on the Apollo Belvedere, the Stag with the Huntress Diana, the Horses of fig. 12, &c.—In isolated Architectural supports : the Candelabrum (fig. 18) in the Duomo at Pietrasanta, (drawn by Mr. George Oakeshott) which was made of the local white *marble* by Stagio Stagi, exhibits thorough knowledge of the material, in the manner in which (in the Profiling) the Minimum-thinness is kept

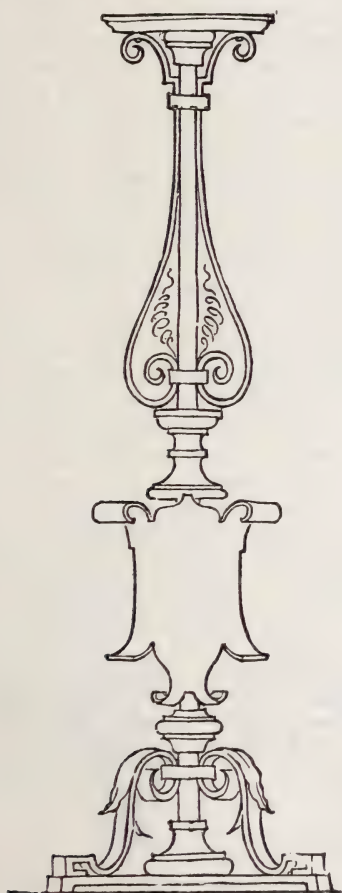


FIG. 20.

sufficiently thick to resist sudden shocks or jars ; and, for a similar reason, extreme Differences of Sectional-area are avoided :

thus the Skotia-mouldings (immediately above and below the vase-like-portion which is decorated by sphinxes and festoons) are one-half of the diameter of the projecting Fillet (top-member of the "vase"), *i.e.* the minimum area is not less than one-fourth of the maximum. In *bronze* the Candelabrum might be designed, as shewn in fig. 19, with less Bulk, and with greater variety of Sectional-area (thus the corresponding Skotia-moulding is less than one-fourth of the diameter of the Fillet, *i.e.* the minimum area is less than one-tenth of the maximum. In Wrought-iron : the Candelabrum might be designed, as shewn in fig. 20, with much less Bulk, and with still greater variety of Sectional-area. It will be further observed that while the Marble example is solid, the Bronze is perforated in the tripodal base, and the Wrought-iron (by reason of the thinness of the bars that are used for the Scrolls) is still more *open* (skeleton-like). Another comparison is seen in fig. 21, shewing a Bracket,

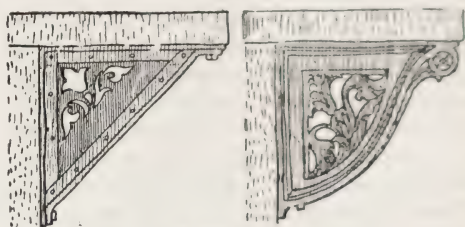


FIG. 21.

supporting a shelf, in which the L.H. sketch shews a wrought-iron treatment ; and the R.H. sketch shews cast-iron. This bracket may be resolved into three factors, which are in two different kinds of strain : the horizontal Top, and the vertical Back against the wall, are in *tensile* strain ; while the oblique Front is in *compressive* strain. In arranging the strength of material to resist each kind of strain, it may be stated that wrought-iron is strong against Tensile-strain, and is weak, and in danger of buckling, when used thin (as in this example) against Compressive strain ; the material is therefore narrow along the tensional Top and Back ; but is broader along the compressed Front. So also, in the R.H. sketch, the cast-iron is (comparatively) thin along the compressed Front ; but is broader along the tensional Top and Back. The material is thus used, in either case, in the most advantageous manner.

DUCTILITY & RIGIDITY, in the elasticity of the Molecular-arrangement, governs the design

of Objects which are fashioned by the operation of hammering a metal plate. In fig. 22 the



FIG. 22.

three sketches shew a Vase, of the same capacity and general mass, made in three different materials. The L.H. one is of *clay*; the centre one is of *silver*; and the R.H. one is of *sheet-iron*. These three Sketches are typical of the three characteristic qualities of: the Plasticity of the *clay*, the Ductility of the *sheet-of-silver*, and the Rigidity (in-ductility) of the *iron-plate*. The *CLAY*, receives shape at the hands of the Potter; and the whole form is homogeneous. The *SILVER*, is hammered, out of flat sheets, into the three portions (Shoulder, Panse, and Stem); and these are joined-together by being soldered to cast-silver mouldings (termed "Mounts"), which are shewn in the sketch at the junctions and at the Lip and Foot. The *SHEET-IRON*, (generally used with a film of Tin on each surface in the manufacture of what is mis-called "Tin-ware" and should be termed "Tinned-ware") cannot be hammered into spherical forms except at great expenditure (though it may be stamped by the aid of machinery); hence it is principally used in making such large objects as have forms that are developable, *i.e.* can be made by bending in *only one* direction, *e.g.* the Cylinder and the Cone; and it will be observed that of the four portions of the Vase in the R.H. sketch: the Neck is *cylindrical*; and the other three portions are *conical*.

FIBROSITY *v* CRYSTALLARITY in the texture, governs the design of Objects made of Wood, &c. (as typical of *fibrous* materials), and of Marble, &c. (as typical of crystalline materials). In the different kinds of wood, Fibrosity and Lateral-cohesion exist in varying degrees: the particular kind will therefore be chosen according to the kind and amount of strain to be borne. In most of the woods which are used in Architecture and Furniture, the fibres run approximately straight, and parallel. That Object will be, therefore, most in accord with the characteristic qualities of

the material, most economical, and most capable of bearing strain, in which the framing-portions are designed on straight lines. In fig. 23, the three sketches shew Objects

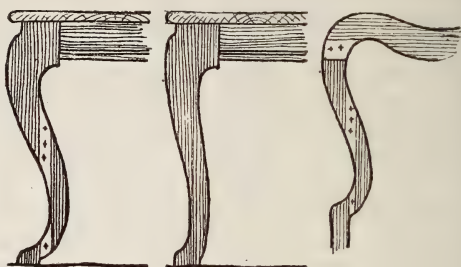


FIG. 23.

made of wood. In the centre sketch, of the Table-leg, it will be observed that some of the fibres of the wood run through uninterruptedly from top to bottom; and this leg will be much stronger than that of the L.H. sketch, the design of which is so much curved that all the fibres are cut-across, twice. So also, in the R.H. sketch, of a Chair-back, the curvature (so dear to the mind of the Shop-walker) destroys the continuity of the fibre in three places. The place-of-fracture is marked by small dots in each case. The above remarks are not intended to condemn all Curves in wood-work; but only to *restrain* curvature within such limits that, in all curved supports, some portion of the Fibre shall run-through *from top to bottom* without interruption. Nor are they intended to condemn the use of the curved Braces that are necessary in Ship-construction, for which purpose the parts of trees that have grown in bent attitudes are selected. CRYSTALLARITY is the characteristic quality of Marble; and renders it less capable of bearing the cross-strain of a horizontal Beam than the compressive-strain of a vertical Support. In fig. 24, the two sketches shew

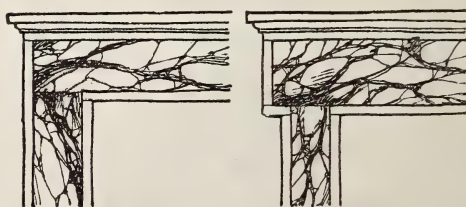


FIG. 24.

Mantle-pieces made of *veined* Marble (which is weaker than homogeneous marble) with white marble Reveals and Mouldings. The L.H. sketch shews the Beam as being the same

bulk as the Supports (and therefore less in strength because of the *cross-strain*): the Beam should be broader, while the Support might be narrower. The R.H. sketch shews the mistake corrected: the Support in compressive-strain is decreased, but is yet sufficient for its load; and the Beam in cross-strain is increased in bulk; and is made longer, in order that it may (theoretically) take some bearing from the adjacent Wall, and be better "bonded-in" to it.

HARDNESS *v* SOFTNESS, like **FINENESS *v* COARSENESS**, in the surface of the material, governs the design of all Objects that have Corners, in positions where there is much Traffic.

TRANSLUCENCY *v* OPACITY, has governed the profiling of the Mouldings, in Greek Architecture. Their profiles have resulted from the use of Marble; and are essentially suitable for marble rather than stone, in the thick cuspidate Fillets (which would appear heavy, in the opaque Stone) and the deeply-cut Quirks (which were necessary to obtain the desired depth of Shadow, in the translucent Marble).

IMPERFECTIONS of the MATERIAL, can be, and are, often disguised by judicious design. Cast-iron, in the process of cooling, sometimes twists and becomes slightly distorted. This departure, from the intended form, is much more apparent in *straight* than in *curved* lines. Hence, in cases where it is desired to save expense, the forms will be broken-up into small curves, as shewn in the sketches, of the Fire-back, and the Coil-case, in fig. 25. Terra-

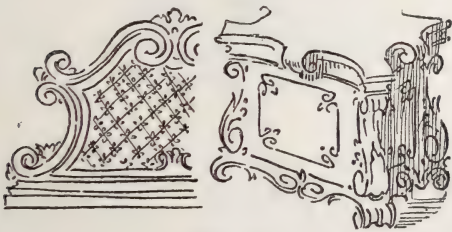


FIG. 25.

cotta is a material which: (a) cannot be made in large pieces; and (b) may twist slightly in the drying. Hence the manner, in which Godfrey Sykes designed the columns in the Quadrangle at South Kensington—arranging projecting Mouldings at the joints; and high-relief Drums alternately with low-relief ones, to prevent the eye running up the Shaft—is worthy of all praise.

RICH MATERIAL, is often used in Slabs or

laminæ to cover masses made of poorer material. Examples are seen in the practice of Veneering with Marble or Wood, and that of Gilding with thin sheets of Gold. This practice is, however, so often associated, with attempts to deceive by unscrupulous people, that it should be used only in such a manner that no deception is possible. Thus in fig. 26

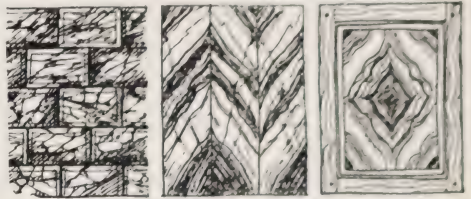


FIG. 26.

the first two sketches shew methods of applying thin slabs of Marble (or the imitation of that material) to Walls. The L.H. sketch shews the slabs, cut to the same size as Stone-blocks, and breaking-joint in the same manner as the blocks are laid in the operation of building a wall; this may produce the impression that the wall is built of solid blocks of valuable marble; and it is directly conducive to Deception. The centre sketch shows the slabs cut to a large size, and placed *vertically* (*i.e.* in such a manner as no wall is ever built), in narrow slabs, which are alternately reversed so that the veining or "pattern" of the marble is reciprocally matched; and the observer sees that they are *veneers* affixed to the building for beauty of colour, and with no attempt to deceive (as has been eloquently demonstrated by Mr. Ruskin). The R.H. sketch shews a wooden Door the panel of which is covered with four pieces of veneer, reciprocally matched. When the veneers, either marble or wood, have the same "pattern", and are thus *matched*: then the observer perceives that they are *contiguous slices* cut from the same block, and *not separate solid blocks*.

IMITATION, in one material of the design in another, must be avoided. Sometimes this has arisen from Veneration of the deeds of Ancestors, as in the Egyptian Pylons, the Dorian Cornice, the Lykian Tombs, or the Indian Caves. Sometimes from Patriotic Motives, as in the Swiss imitations of Wooden architecture that are made in stone and brick. Sometimes from Vis-inertia and Indolence, to save the trouble of thinking, which reason or motive will be avoided by every true Artist. Each Material has its own individual beauty of Colour

or Texture; and—to overlook this in order to make it simulate the treatment of some other—is one of the surest means to attain to Vulgarity.

CONSTRUCTIONALITY governs design as it relates to the putting-together or fastening-together of the several portions of which an Object is composed. The act, of fastening-together, is termed Construction. When any portion or feature is an integral part in the putting-together, it is said to be Constructional. And the artistic quality—of being designed in such a manner that the Act of putting-together is *not hindered*, and the Result of that act is *not hidden*—is termed Constructionality.

The CONSTRUCTION, of any Object, may be:—(a) acknowledged and glorified—(b) ignored—(c) supplanted—and (d) confused.

The ACKNOWLEDGEMENT is seen most clearly in Architecture. The RUSTICATION of Wall-joints is one much-used method. It will be observed that, when a Stone-block rests upon the whole of its under-surface, the edges

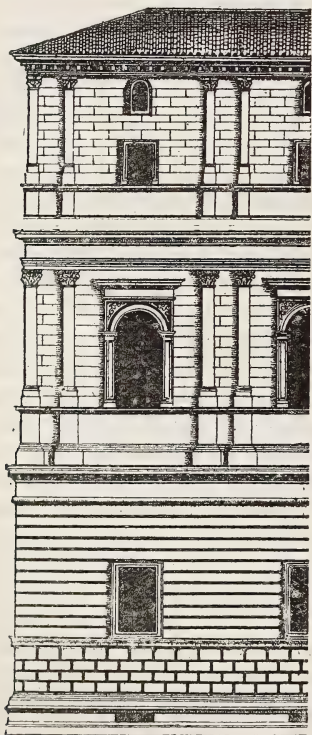


FIG. 27.

are liable to chip-off. This is obviated by chamfering the edges, making Grooves; with the result that the Bearing-surface is recessed a small distance; and the chipping-off is rendered impossible. This Grooving, as well as preventing the chipping-off, gives an artistic

quality to the face of the Wall; and the observer assesses the thickness of the Wall, by the distance-apart and the coarseness of the Grooves. The Wall of the lower storeys of a building, having more weight to support than the wall of the upper storeys, is made gradually thicker, in proportion to the load upon it; and this fact may be shewn by different degrees of coarseness in the Rustication, as is shewn (partially) in fig. 27.

The STRING-COURSE has important functions in Walls that (a) have Floor-beams resting upon them, or (b) are pierced with windows and have therefore alternate *Piers* and *Voids*. The Stones, of the Course immediately under each storey of Floor-beams, should each be, *long* (for the purpose of spreading the bearing), and *hard* (that it may not break, under the strain). They will come-through to the face of the wall; and they are generally designed to project a few inches in front of the general surface; and are often decorated



FIG. 28.

by means of carved Mouldings upon them. The Stones, of the Course that is level with the Window-sills, will similarly distribute the weight over a wider bearing-surface, when long and hard, than if they were similar to the ordinary stones of the wall; and they also are designed to project, and decorated by mouldings. Both of these String-courses—the Floor-string and the Pier-string—are shewn in fig. 27, and also (more clearly) in fig. 28. The ANNULET on the shaft of engaged Columns and Pilasters has constructional value. The Piers of the Nave-arches, in the Early English period (which were designed as if bundles of columns) are connected or bound-

together (in appearance, and often in reality) by Annulets. Those shewn, in fig. 29,

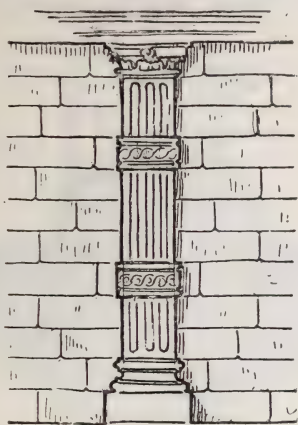


FIG. 29.

have the effect of making the Pilaster more an integral portion of the Wall than if it

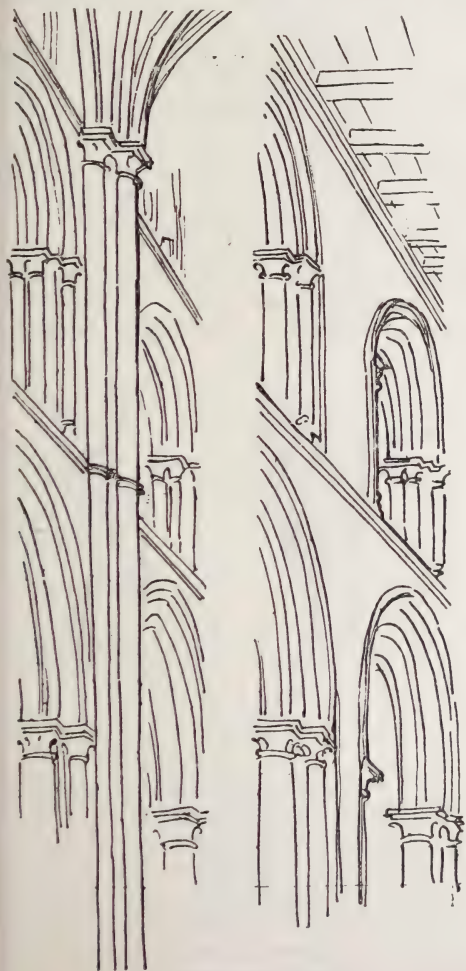


FIG. 30.

were merely placed-against the wall without them. The VAULTING-SHAFTS in our noble Gothic Cathedrals are admirable examples of Constructionality. Each of the two sketches, in fig. 30, shews the interior of a Nave. The R.H. sketch shews a wooden Ceiling (under the roof) and, in this, the row of ceiling-joists is distributed (at short intervals) along the String at the top of the Wall; and there is no special need for making (or *suggesting*) that any one part, along the wall, needs to be stronger than any other; the Design is therefore perfectly consistent. The L.H. sketch shews a stone Vault, in which the Vaulting-ribs are gathered-together, to spring in groups, from particular places between the Clerestory-windows; and there is therefore a need that the wall should be (and *appear*) stronger under these places; and hence the design of these Vaulting-shafts.

DISREGARD of Constructionality, is shewn in many objects; but one example may be given, in the Framed-panelling, which is sometimes attempted with *flush* panels. This method does not acknowledge the styles; and generally, when the wood shrinks and the joints open, it exhibits the faultiness of the design.

SUPPLANTING the Construction is generally perpetrated by those possessing more



FIG. 31.

cleverness of imitation than logicity of perception. In this breach of good taste, the artist, instead of decorating an Object with some feature that he has chosen, substitutes his Feature for the object. Thus, in fig 31, a



FIG. 32.

Salad-bowl is shewn as if composed of natural Cabbage-leaves. There is no objection to

natural leaves as a *decoration* to a Bowl ; but in this example the leaves *are* the Bowl, *i.e.* they have supplanted the Object they were intended to decorate. The sketch in fig. 32 suggests how they may be used without destroying the Bowl. In fig. 33 the L.H. sketch



FIG. 33.

shews the Arm of a Chair at S.K.M., in which the Dolphin *is* the Arm ; and the R.H. sketch shews the fish as “decorating” the Arm. In fig. 34, the Harp (taken from the Irish quarter-



FIG. 34.

ing of the Arms of the United Kingdom) is designed, as shewn in the L.H. sketch, in such a manner that the Strings must be screwed into the lower edge of the Wing-feathers of a Victory-terminal-figure ; and in the R.H. sketch the Figure is shewn, *not* as *supplant-*



FIG. 35.

ing but as decorating the Harp-frame. Perhaps, however, the most interesting examples are seen in the two figs. 35 and 36, in one of

which a Nautilus-shell (somewhat altered) serves as the lip-spout of the Ewer ; and, in the other, a sitting Swan discharges the water



FIG. 36.

between its wings ; and (by obligingly keeping tight hold of some leaves in its beak) serves the function of a handle by its neck.

In the CHANGE of the MATERIALS of which any constructional Feature is made : there is always a danger in applying the same section or the same decoration to both materials. The student will be on safer ground if he or she change the Treatment at the change of Material. In a well-known church in South London, there are wooden ribs which abut against stone ones ; and the Rib-moulding is carried-through both without any break of treatment (in section or otherwise). In fig. 37,

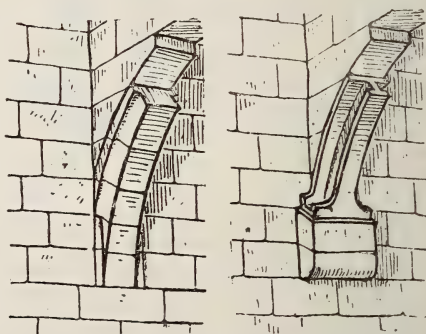


FIG. 37.

the L.H. sketch shews a stone Rib, springing from a stone Wall, and supporting a small transverse stone Wall ; and in the R.H. sketch, (which shews an *iron* Rib resting on a stone Corbel, for performing the same duty) the change of material is emphasized ; and the characteristic quality of each, when in construction, is thereby preserved.

Miscellaneous.

THE MINING INDUSTRIES OF NEW SOUTH WALES.

Gold mining was, for but a brief period, the leading industry of New South Wales, but at the present time it yields in importance to silver, and sometimes to coal. Although the settlement of New South Wales has not been affected by the discovery of gold to the same extent as that of Victoria, yet the number of persons engaged in actual search for the precious metal was at one time considerable. This number, however, has gradually decreased, as the fields have been despoiled of the treasures contained in their easily-worked alluvial deposits, and many of the gold miners have turned their attention to the silver, copper, and tin mines, and the coal and shale mines also find occupation for large numbers. The date of the discovery of gold in New South Wales was for a long time the theme of much controversy, and the question as to the original discoverer was long disputed. It is now agreed, however, that the existence of gold was known to the authorities during the early days when the colony was a convict settlement, but for obvious State reasons the matter remained a secret. Native gold is the only true mineral species of gold which has so far been found in New South Wales, and was first met with in easily-worked alluvial deposits. Although the alluvial deposits, discovered in the early days, have been practically abandoned, and are considered to be worked out, there is, according to the Government statistician of New South Wales, ample evidence that the surface of the country has been merely scratched. The search for gold has been vigorously prosecuted for more than 45 years, and still new gold fields and fresh deposits are being discovered—in localities, too, supposed to have been thoroughly examined. Gold is also found in quartz veins, in conglomerates in the coal measures at Tallawang, and in carboniferous strata. The total production of gold in 1896 amounted to 296,076 ounces, valued at £1,073,360, and although this production was not so high as in 1894 and 1895, it exceeded that of any other year since 1873. The gold found in New South Wales is never absolutely pure, always containing traces of other metals, such as copper, iron, and bismuth, and often a fair percentage of silver. To the presence of silver its bright colour is due. New South Wales gold is generally lighter in colour than Victorian gold, but is of a deeper yellow than that found in the fields of Southern Queensland. Its specific gravity averages about 17·5. Up to the year 1882 the quantity of silver raised was very small, but in that, and the following years, extensive discoveries of this metal, associated principally with lead and copper ore, were made in various parts of the colony, notably at Boorok, in the New England district, and, later on, at Sunny

Corner, near Bathurst, and at Silverton, Broken-hill, and other places on the Barrier Range. Since the year when silver was first discovered down to the end of 1896, the value of silver and silver lead exported from New South Wales amounted to £22,410,046. The world's production of silver, in ounces, during the ten years ended 1896 has been estimated as follows:—1887, 96,124,000; 1888, 108,827,000; 1889, 120,214,000; 1890, 126,095,000; 1891, 137,171,000; 1892, 152,940,000; 1893, 162,162,000; 1894, 178,668,000; 1895, 182,220,000; and 1896, 186,042,000 ounces. The annual output of New South Wales is about one-twelfth of the total production of silver. Tin has contributed in a very considerable degree to the general development of the natural wealth of the colony, and in point of value its aggregate production stands in the fourth place—next to gold, coal, and silver. For the years 1881 and 1882, the value of the production of tin was even in excess of that of gold; the export during 1894, 1895, and 1896, however, was the smallest since the opening of the tin fields. Although tin mining is now one of the settled industries of the country, and the supply is practically unlimited, the quantity raised depends almost entirely upon the price realised. In 1896 the value of the exports of tin only amounted to £68,546, but within the twenty-five years that have elapsed since the opening of the tin fields, the value of the exports has been £6,196,518. The copper mining industry, which at one time attained considerable dimensions, reached its highest point of production in 1883, but from that year there was a considerable falling off in consequence of the decline in the price of the metal. There is now, however, a gratifying revival in the industry, and the prospects for the future seem to be of a favourable character. The copper lodes of New South Wales contain ores of a very much higher per-centage than those of many well-known mines worked at a profit in other parts of the world. The value of the exports of copper in 1896, was £197,814—the highest production since the year 1888. Iron is widely diffused throughout the colony, and occurs principally in the form of magnetic brown hematite or goethite, limonite, and bog iron. Deposits of chrome iron are also found. Magnetite is the richest of all the iron ores, sometimes containing a little over 72 per cent. of available metallic iron, though it is not often found reaching this very high per-centage; and the ores are widely distributed throughout New South Wales. Brown hematite or goethite occurs in very extensive deposits in the Blue Mountain ranges. Limonite—a variety of brown hematite—principally occurs at Lithgow, Eskbank, and Bowenfels, in the Blue Mountains, in the Hunter River Coalfield, and in the Illawarra district. Bog iron ore, which is impure limonite, is principally found at Mittagong, and assays of this ore gave an average per-centage of metal of more than 45 per cent. Deposits of antimony occur in the colony in various places, and the principal centre of this industry is at Hillgrove, near Armidale, where the Eleanora Mine,

one of the richest in the colony, is situated. The ore is also worked for gold. The value of antimony raised during 1896 was £1,834. The antimony industry has suffered greatly during the last two years from the low price of the metal, and the output is not likely to improve until the price takes an upward tendency. Deposits of manganese ore have been discovered in various parts of New South Wales, and the ore is found extensively in conjunction with iron in coal and limestone country, and often contains a small per-centage of cobalt. Bismuth is found associated with molybdenum and gold in quartz veins in the neighbourhood of Glen Innes, whence the quantity raised has been chiefly obtained. The largest mass of native bismuth yet discovered in the colony weighed more than 30 lbs. Platinum is found in inconsiderable quantities, and mercury in the form of cinnabar has been discovered. Cobalt, chromium, tellurium, wolfram, and zinc are found. Coal was first discovered in the colony in 1797, and, to the end of 1896, the total quantity extracted from the New South Wales mines, from their opening, amounted to 72,282,266 tons, valued at £31,819,331, the quantity raised in 1896 amounting to 3,909,517 tons. The number of coal mines under inspection in New South Wales at the end of the year 1896, was 96, being a decrease of 3 from the figures of 1895. They gave employment to 9,233 persons, of whom 7,538 were employed under ground, and 1,695 above ground. The wealth of the colony in coal is enormous, and the further expansion of the industry may be regarded as almost certain. As the great Australian continent is only in the early period of the development of its immense resources, so also may the coal mining industry of New South Wales be said to be in its infancy. New South Wales coal is said to compare favourably as a heat producer with the best foreign coal. It has the advantage of a greater specific gravity, and it contains less sulphur. The existence of diamonds and other precious stones has been known for many years, but no attempt was made to work the deposits until the year 1872. In the course of the following year several deposits of diamantiferous wash were discovered in the country near Inverell, in the New England district. The number of diamonds found in the colony to the end of 1896 is estimated at 107,000, the largest being one of 5½ carats or 16·2 grains. The diamonds occur in old tertiary river drifts and in the more recent drifts derived from them. The deposits which occur in the Inverell, Bingara, Mittagong, Cudegong, and Narrabri districts are extensive, and have not yet been thoroughly prospected. The best of the New South Wales diamonds are harder and much whiter than the South African diamonds, and are classified as on a par with the best Brazilian gems. Other precious stones, including the sapphire, emerald, oriental emerald, ruby, opal, amethyst, garnet, chrysolite, topaz, cairngorm, onyx, &c., have been found in the gold and tin bearing drifts and river

gravels in numerous localities throughout the colony. Mica is known to exist in many parts of New South Wales, but has never yet been worked, although there is a considerable demand for the article. Asbestos has been found in veins in serpentine, and alunite occurs as a large deposit in the district of Port Stephens. The colony possesses a most abundant supply of all the various kinds of stone and other materials for the building and adornment of its cities.

DOGS AS DRAUGHT ANIMALS IN BELGIUM.

In the western portion of Belgium, including the two Flanders, the dog has been employed beyond the memory of man as a beast of burden. There are various kinds of dogs in use for this purpose, large, medium sized, and small dogs, strong and weak dogs, smooth coated as well as shaggy dogs. The Belgian dog, the breed being known only by this name, is a large, compactly built animal; when upright, he measures in height from 20 to 30 inches; the hair is smooth and short; generally tan or dark brown in colour. Both his tail and ears are cut short, the former, because it is believed that the strength which would otherwise enter into this extremity is retained in the spinal column and haunches, and the latter in order to prevent the constant flapping of the naturally long ears, which would be a great inconvenience and hindrance to their work when annoyed by flies. The United States Consul at Ghent says that this specimen of dog has been employed in Flanders for years unnumbered. These dogs are seldom harnessed single, but are usually driven two, three, four, five, or even six abreast. Five or six of these animals can easily draw a load of 600 or 800 pounds for a considerable distance, and during several consecutive hours. The level plains of western Belgium and Holland are especially suitable for the employment of dogs for hauling purposes. While in mountainous regions they are not practicable for heavy loads, still in slightly undulating country they are able to out-distance horses for long-distance hauling. For example, the distance between Ghent and Brussels is thirty-four miles; ordinary horses require four hours to cover it, while a team of dogs will easily go over the ground in three hours without any apparent fatigue. A good team of two to four dogs will draw a pedlar's load from 5 a.m. to 8 p.m. with only such short intervals of rest as they may obtain during the sale of goods. The Belgian dog may be put to work when about a year old, and can be employed daily for eight or nine years. He generally lives to be ten or eleven years of age. After death the skin is still of value for tanning purposes. The training of these animals is very simple. It is customary to fasten the young dog, when about six months of age, alongside experienced dogs and with-

out giving him any load to draw, thus to teach him to run in harness. The prices of the dogs vary. Young ordinary dogs sell for about 25s. to 30s., a good specimen between one and three years of age brings 40s. to 50s., while a very fine animal will cost 60s. The number of dogs employed as draught animals in Belgium is very considerable, but exact statistics on this subject are not obtainable. According to the police registers of Ghent, 2,037 dogs are licensed as draught animals in that city. These animals are exempt from the tax imposed on pet house dogs, which number 3,775 in Ghent, for a population of 160,000. Properly speaking, there is no organised trade in these animals anywhere in Belgium; dog markets are held, but the only people who frequent them are small farmers or merchants who may have an extra dog not necessary for their business which they may wish to sell. There are no efforts to improve the breed, and in all probability by reason of the hap-hazard crossing with other breeds it is more likely degenerating. Consul Morris has been informed by an authority in Belgium that in this respect improvement could be made, as if there were a systematic and scientific crossing of the Belgian dog with the Ulm dog or Great Dane a better breed would be obtained. Such efforts have, however, never been made in the country as the market price of dogs does not justify the expense. The food and maintenance of the dogs are trifling items of expense, one large dog being able to subsist on the kitchen waste of a household of five or six persons. Properly speaking, daily meat is indispensable, but very few of the Belgian animals get it. In the country districts the dogs' food is exclusively milk, bread, and vegetables, but still he seems to thrive upon it and to be healthy. The carts in ordinary use weigh about 100 or 120 pounds. The harness is a horse's equipment in miniature, the only peculiarity of it, is that the pad or saddle placed on the back is relatively much thicker and stronger than in the harness of a horse. A good set of harness made of leather costs from 5s. to 8s. It may be taken that the general and common use of dogs as draught animals throughout Belgium tends to prove that under the conditions existing there they are a great economy and an important factor in the labour question.

THE FOREIGN POPULATION OF GERMANY.

The foreign population of Germany is not a large one, since the proportion is only .93 per cent. of the total population, while in Belgium it is 2.80, in France 2.97, and in Switzerland 7.7 per cent. In December, 1871, the foreign population of the Empire numbered 206,755 persons, but at the last census enumeration (December, 1895), this number had risen to 486,190, or an increase of 135.2 per cent. within the space of a quarter of a century. In France the number of foreigners increased by 38 per cent. only from 1871 to 1896, passing from 740,600 to 1,027,491.

An interesting point to note in the population statistics of the German Empire, is the small number of foreigners in Berlin, only 27,000, a figure below that of the foreign population of Vienna (34,954 in 1890), of London (95,033 in 1891), and particularly of Paris, in which city there are 180,000 foreigners. The foreign population of Berlin, small as it is, has nevertheless increased of late years; it was only 17,866 in 1891, so that in five years there has been a gain of 55.6 per cent. As regards the nationalities of the foreign residents, Austro-Hungarians head the list with a total of 222,952 persons, Dutch come next with 50,743, Swiss 44,875, Danes 28,146, Russians 26,559, Italians 22,633, French 19,619, English 15,292, Americans 15,788, other races 39,525. As regards the distribution of the sexes, the foreign population of Germany differs from that of France. In the latter country the proportion is 86 women to 100 men, while in Germany the proportion of the sexes, as regards the foreign population, is as follows:—78 women to 100 men. If the aggregate population of the Empire be taken, the proportion would be 103 women to 100 men. In Berlin the proportion of women to men is 82 per cent., and this rate falls in the provinces of Prussia, in Westphalia, and reached its minimum in Pomerania—49 per 100 men. The proportion of women is highest in Saxony. As regards the civil condition, the profession, and the religion of the foreign population of Germany, there are no official data as yet available.

THE LIBRARY.

The following books have been presented to the Library since the last announcement.—

British Columbia.—The Year-book of British Columbia, and Manual of Provincial Information. (Victoria, B.C.) Presented by the Agent-General.

Carus-Wilson, Professor C. A., M.A.—Electro-Dynamics: the Direct-current Motor. (London: Longmans, Green, and Co., 1898.) Presented by the Publishers.

Cheetham, T. A.—Elementary Chemistry, Practical and Theoretical: First Year's Course. (London: Blackie and Son, 1898.) Presented by the Publishers.

Cowie, Andson.—English-Sulu-Malay Vocabulary, with Useful Sentences. Edited by Wm. Clark Cowie. (London, 1893.) Presented by the Editor.

Grey, Henry.—The Classics for the Million. (London: John Long, 1898.) Presented by the Author.

Heaton, Aldam.—Beauty and Art. (London: Wm. Heinemann, 1897.) Presented by the Author.

Hull, Edward, LL.D., F.R.S.—Our Coal Resources at the Close of the Nineteenth Century. (London: E. and F. N. Spon, 1897.) Presented by the Author.

Ives, Frederic.—Krömsköp Color Photography. (London: Photochromoscope Syndicate, 1898.) Presented by the Author.

Kingzett, C. T. and D. Homfray, B.Sc.—A Pocket Dictionary of Hygiene. (London: Baillière, Tindall, and Cox, 1898.) Presented by C. T. Kingzett.

Newth, G. S.—A Manual of Chemical Analysis: Qualitative and Quantitative. (London: Longmans, Green, and Co., 1898.)

Schreiner, S. C. Cronwright.—The Angora Goat. (Published under the auspices of the South African Goat Breeders' Association, by Longmans, Green, and Co., London, 1898.) Presented by the Association.

Spons' Architects' and Builders' Price Book. By W. Young. (London: E. and F. N. Spon, 1898.) Presented by the Publishers.

General Notes.

THE POPULATION OF EGYPT.—During the last hundred years the population of Egypt has shown a constant increase. In 1800 it consisted of 2,460,200 souls, in 1846 this number had increased to 4,476,440, and in 1882 to 6,813,919. At the present time the population is estimated at 9,734,405, and if it continues to increase in the future in the same proportion as in the past it will amount by the year 1912 to about 12,000,000. As regards the distribution of the sexes, there are 4,947,850 males and 4,786,555 females, and these figures include 112,526 foreigners. France has supplied 14,155, the United Kingdom 19,557. The most numerous of the foreign inhabitants are the Greeks, who number 38,172, then come the Italians, 24,467, and (after the French and English) Austrians 7,117, Russians 3,193, Persians 1,301, Germans 1,277, Spaniards 765, Swiss 472, Americans 291, Belgians 256, Dutch 247, Portuguese 151, Swedes and Norwegians 107, Danes 72, and 923 of other nationalities. In Lower Egypt there are 5,676,109 inhabitants and in Upper Egypt 4,058,296. Public instruction leaves much to be desired, for of the entire population only 467,886 persons are able to read and write, there are therefore 9,266,819 inhabitants, or 95 per cent. of the aggregate population completely illiterate. What is even more extraordinary is the fact that 6,486,498 persons, or about two-thirds of the entire population, are without any trade or profession.

HIGHER EDUCATION IN SAXONY.—A report has recently been made by the United States Consul at Chemnitz, upon the "further developing" schools of Saxony. With a population of 3,783,014 the kingdom has 1,953 of these schools, with 75,358 boys and 1,699 girls in attendance. Besides these there are 39 higher industrial schools, with 10,660 scholars; 112 industrial technical schools, with 10,119 scholars; 44 commercial schools, with 4,781 scholars; 11 agricultural schools, with 691 scholars; 7 schools of all kinds of work for girls, with 1,569 scholars, and 18

technical schools for girls, with 2,445 scholars. Saxony's wonderful wealth, her industrial greatness, and the fact that she sends out to other parts of the world vast quantities of all kinds of wares, toys, textiles, tools, and machines, attest the importance of these schools. To explain just what is meant by the term "further developing," the Consul adds that the system of common school education under which boys and girls were given an ordinary training up to their fourteenth year was found inadequate. Compulsory education was established for graduates of the common schools. The hours of attendance are early in the morning or a certain number of afternoons each week. Manufacturers, merchants, &c., are made responsible for the attendance of the boys in their employ, and the latter make a special study of the trade in which they are occupied.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, OCT. 31...Farmers' Club, Salisbury-square Hotel, Fleet-street, E.C., 4 p.m. Mr. W. Anker Simmonds, "The (New) Agricultural Holdings Act."

TUESDAY, NOV. 1...Central Chamber of Agriculture (at the HOUSE OF THE SOCIETY OF ARTS), 11 a.m.

Civil Engineers, 25, Great George-street, S.W., 8 p.m. Inaugural Address by the President. Mr. W. H. Preece.

WEDNESDAY, NOV. 2...Sanitary Institute, 74A, Margaret-street, W., 8 p.m. Dr. Alfred Hill, "Diseases of Animals in relation to Food Supply."

THURSDAY, NOV. 3...Linnean, Burlington-house, W., 8 p.m. 1. Prof. H. Marshall Ward and Miss Dale, "*Crate-rostigma pumilum*, Hochst." 2. Rev. T. R. Stebbing, "Amphipoda from the Copenhagen Museum and other Sources. Part II." Exhibitions:—1. Prof. Howes, Embryos of *Hatteria*. 2. Mr. Alan F. Crossman, Photographs of Chicken with foster-parent a Common Buzzard. 3. Messrs. H. and J. Groves, *Nitella hyalina*, Ag., a new British Plant.

Chemical, Burlington-house, W., 8 p.m. 1. Mr. George Dean, "A Determination of the Equivalent of Cyanogen." 2. Mr. E. Sonstadt, "Note on the Action of Light on Platinum, Gold, and Silver Chlorides." 3. Mr. E. H. Bagnall, "Methane-trisulphonic Acid." 4. Mr. W. J. Pope, "A Composite Sodium Chloral Crystal in which the Twin-law is not followed." 5. Dr. Sydney Young, "The Composition of American Petroleum." 6. Drs. F. E. Francis and Sydney Young, "The Separation of Normal and Iso-heptane from American Petroleum." 7. Mr. D. H. Jackson and Dr. Sydney Young, "The Boiling Points and Specific Gravities of Mixtures of Benzene and Normal Hexane." 8. Drs. F. E. Francis and Sydney Young, "The Action of Fuming Nitric Acid on the Paraffins and other Carbons."

FRIDAY, NOV. 4...Sanitary Institute, 74A, Margaret-street, W., 7 p.m. Mr. Henry R. Kenwood, "Infectious Diseases and Methods of Disinfection."

Geologists' Association, University College, W.C., 8 p.m. Conversazione.

Journal of the Society of Arts.

No. 2,398. VOL. XLVI.

FRIDAY, NOVEMBER 4, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.**ARRANGEMENTS FOR THE SESSION.**

The First Meeting of the One Hundred and Forty-fifth Session will be held on Wednesday evening, the 16th of November, when an Address will be delivered by SIR JOHN WOLFE BARRY, K.C.B., M.Inst.C.E., F.R.S., Chairman of the Council.

Previous to Christmas there will be four Ordinary Meetings, in addition to the Opening Meeting. The following arrangements have been made :—

NOVEMBER 16.—Opening Address by SIR JOHN WOLFE BARRY, K.C.B., M.Inst.C.E., F.R.S., Chairman of the Council.

NOVEMBER 23.—“Long Distance Transmission of Electric Power.” By PROF. GEO. FORBES, F.R.S.

NOVEMBER 30.—“Photographic Developers and Development.” By C. H. BOTHAMLEY, F.C.S.

DECEMBER 7.—“Egypt and the Soudan, in 1897 and 1898.” By W. T. MAUD.

DECEMBER 14.—“Commercial Education.” By SIR ALBERT ROLLIT, LL.D., M.P.

Papers for meetings after Christmas :—

“Tuberculosis in Animals.” By W. HUNTING.

“Canals and Inland Navigation in the United Kingdom.” By L. F. VERNON-HARCOURT, M.A.

“Preservation of Timber.” By S. B. BOULTON.

“Electric Traction and its Application to Railway Work.” By PHILIP DAWSON.

“Coal Supplies.” By T. FORSTER BROWN.

“Wireless Telegraphy.” By W. H. PREECE, C.B., F.R.S.

“Leadless Glazes.” By WILTON P. RIX.

INDIAN SECTION.

The meetings of this Section will take place on the following Thursday afternoons, at 4.30 o'clock :—

January 19, February 9, March 9, April 13, May 11, 25.

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesday afternoons, at 4.30 o'clock :—

December 6, January 24, February 28, April 25.

At the meeting before Christmas the following paper will be read :—

TUESDAY, DECEMBER 6.—“The Yangtse Basin and the British Sphere.” By ARCHIBALD LITTLE, F.R.G.S., of Chungking.

*** Numerous lantern slides of the Upper Yangtse and beyond will be shown and described by Mr. LITTLE.

APPLIED ART SECTION.

The meetings of this Section will take place on the following Tuesday evenings at 8 o'clock :—

January 31, February 21, March 14, April 18, May 2, 30.

CANTOR LECTURES.

The following courses of Cantor lectures will be delivered on Monday evenings, at 8 o'clock :—

PROF. VIVIAN B. LEWES, “Acetylene.” Four Lectures.

LECTURE I.—NOVEMBER 21.

The history of acetylene—Methods of formation—The chemistry of acetylene—The part played by acetylene in ordinary luminous flames.

LECTURE II.—NOVEMBER 28.

The commercial production of acetylene—Calcic carbide and its properties—The electric furnace and the various modifications in use for carbide manufacture—Carbide without electrical power—Carriage and storage of carbide.

LECTURE III.—DECEMBER 5.

The commercial generation of acetylene—The types of generator in use—The actions taking place in acetylene generators, and the effect upon the gas produced—The purification of acetylene for domestic consumption.

LECTURE IV.—DECEMBER 12.

The combustion of acetylene—Acetylene burners—Smoking and carbonising of burners—Burners for heating—Acetylene for gas engines—Diluted Acetylene and its applications.

DR. SAMUEL RIDEAL, “Bacterial Purification of Sewage.” Four Lectures.

January 16, 23, 30, February 6.

ARCHIBALD SHARP, A.M.Inst.C.E., “Cycle Construction and Design.” Four Lectures. February 20, 27, March 6, 13.

PROF. HENRY R. PROCTER, “Leather Manufacture.” Four Lectures.

April 10, 17, 24, May 1.

JUVENILE LECTURES.

Two Lectures, suitable for a Juvenile audience, will be delivered on Wednesday evenings, the 4th and 11th of January, at Seven p.m.

Proceedings of the Society.

CANTOR LECTURES.

SOME PRINCIPLES OF FORM-DESIGN IN APPLIED ART.

BY HUGH STANNUS, F.R.I.B.A.*

Lecture IV.—Delivered 7 March, 1898.

The MASS-SHAPE, or MASS-FORM, of Objects, is governed by a group of Laws, of which the Law of ACCENTUATION is one extreme; and the Law of MOLLIFICATION is the other. (The intermediate Law, in regard to the Shape or Form, is the Law of DECISION; and that, in regard to Surface, is the law of BREADTH.) Thus, in regard to the Shape of the quadrate Figures, in fig. 38: the central sketch, marked

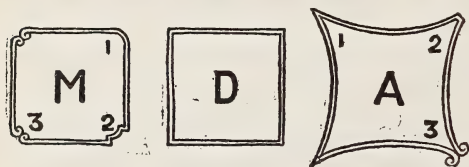


FIG. 38.

D, is the normal or intermediate shape; the R.H. sketch, **A**, is accentuate; and the L.H. sketch, **M**, shews the angles as softened or mollified. So also, in regard to the Form of the Object (a Gable), in fig. 39: the central



FIG. 39.

sketch, marked **D**, is the normal or intermediate form; the R.H. sketch, **A**, is accentuate; and the L.H. sketch, **M**, shews the corner as mollified. In regard to Surface: *vid. seq.* the Law of Breadth.

ACCENTUATION is the first of the group of Laws which govern the design of Mass. The term is derived from two Latin words which signify the *singing* (some parts of a melody) *with more energy* (than the remainder). The first Note of each Bar is, usually, thus marked (for Time-measuring reasons)†; but other Notes are also sounded with energy, for *Expression* as a part of the Design of the Tone-artist. So also, in other Applied-arts —

when one Sentence or Word is enunciated with *more energy* than the remainder of the Oration—one Feature or Detail is marked *with more energy*, in Projection, in Mass-shape beyond the general mass of the Object, or in Relief in front of the general surface of the Ground, or in Colour, stronger than the general Tint or Tone—then it is said to be “accentuated”.

EXAMPLES are seen:—in NATURE: in the Eye-brows, and Lips, for Colour; and in the Moustache, Beard, Mane, and Tail, for Form—in DRESS: in the Cocked-hat with its *turned-up* or “cocked” brim; the curved brim of the ordinary high Hat; and the Epaulettes—in ARCHITECTURE: in the Gablet at the top of the Hipped-roof (sketch **A**, in fig. 39); the Akroters on the Pediment (fig. 11, p. 902); the Anta or thickening of the Wall-end in a Greek Temple; the projecting horns of the Korinthian-abakos (sketch **K**, in fig. 6, p. 898); the Cornice at the Wall-top (figs. 27 and 28, p. 914); the Arris between each two flutes of the Dorian Column-shaft (but see last paragraph of Functionality, in Lecture I); the Quirking and Cusping of Greek Mouldings; and the Hood-mould in the Decorated-period—in PROFILING, &c.: in the late Greek Sepulchral-vase, two of which, from the Central Museum at Athens, are shewn in the first two sketches of fig. 40 (these err against the Law of Materiality by reason of the projecting Lips and Bases and the thin Handles, which would be broken in daily use; they were, however, not for use but were made cheaply in Clay, to be placed as Symbols upon the Tombs); the Greek Bedstead-leg, shown in the third sketch of fig. 40,



FIG. 40.

* All rights in these four lectures are reserved by the author.

† The time-measuring Accentuation is analogous to the Law of Repetition; and will be treated of under that head.

exhibits Accentuation in a very marked degree in the (unnecessary) projection of the Fillets; the Tassel at the extremity of the Cord; and the Serifs in Typography.

INCREASE of ACCENTUATION will be seen on comparing the sketches in fig. 41: in **a**, is seen a Spiral with an obscured end (somewhat similar to a Lituus): in **b**, the two parts are separated by the interpolated vertical straight-line: in **c**, the upper part is more curved, and

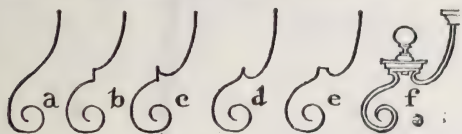


FIG. 41.

makes a tangent with the straight-line: in **d**, the lower part is made to curve out, making a tangent with the upper: in **e**, the two tangential parts are separated by the interpolated horizontal straight-line: in **f**, the two parts are still more curved, making tangents with the horizontal line. Thus **b** may be said to be normal; **c** is accentuated; **d** is more accentuated, with *one* centre of Radiation; and **f** is an extreme case, with two centres of Radiation. The Violin-body, as finally settled in its present canonical shape, shews Accentuation. The Rib had been originally of *one* piece of wood, curving inwards to enable the Bow to touch the Strings; and so obviating the other alternative, *i.e.* the high Bridge; but the seventeenth century was a time of Accentuation in Art; the violin did not escape its influence; and the Rib was made in five pieces with two cusps on each side. In fig. 42, are shewn some sketches for Bracket-sides: the first one, **D**, shews the projection obtained by the convex quadrant and the square: in **M**, these are coalesced, making a Cyma-recta shape: in **A1**, the upper portion of (hollow) shape is more curved,

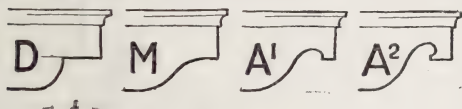


FIG. 42.

making a tangent to the vertical face, this being the first stage of Accentuation: and in **A2** the upper portion is still more curved making a tangent to the horizontal sofit, thus being a second stage of Accentuation. In the R.H. sketch, **A**, of fig. 38, three degrees (numbered) are further shewn.

The APPLICATION of this LAW (of expressive Accentuation) is an expedient for preserving the

attention of the listener or beholder; but it should not be too often applied, lest it defeat its own end. It is like the "seasoning" in Gastronomy. If the Food were all pepper or mustard, then the Palate would soon lose all relish; and so with Accentuation: it must be used sparingly, as a seasoning; and the student should ever remember that — "In medio tutissimus ibis."

BREADTH is the second of the group of Laws which govern the design of Mass. It prescribes that, though Details, of important Features or in important Positions, may be prominent, for good and sufficient reasons, yet the General-surface shall be treated in such a manner that it be not frittered-away or cut-up into too many small parts, that would militate against each other, and destroy the Simplicity and Unity of effect which should characterize every good Composition. Hence it is, in some degree, antithetical to Accentuation; though it may be applied and coexist in the same Object, as shewn in fig. 43 (the Archi-



FIG. 43.

trave-cornice of the Pandroseion), in which the Dripping-edge of the Corona shews Accentuation; and the Architrave-fascias with the Ogee and the Dentil-sofits shew Breadth.

EXAMPLES are seen:—in NATURE: in the continuous line of the Mountain-sierra; the circumscribing-line of Trees, Flowers, and Leaves, of Feathers, Wings, Fins, Paws, and Hands, and in the Bodies of all Animals, in which, though Muscles of different function combine to make the form, yet the Skin-covering blends all into undulating forms of infinite and indescribable changeful Beauty—in ARCHITECTURE: in the dignified Simplicity-of-surface of the Strozzi Palace, in Firenze, as compared with the trifling littleness of the Hotel-de-Ville, at Paris; or in the Palace-front of fig. 28, as compared with the Church-flank of fig. 9 (p. 901) - in PROFILING: in the three sketches of fig. 44, in which the general Mass-

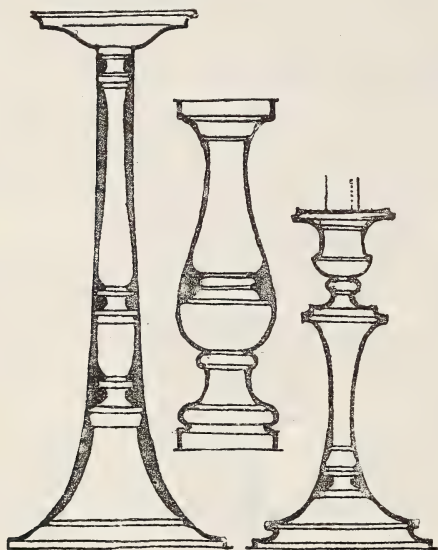


FIG. 44.

form is as shewn by the black Line, while the Individual-mouldings are kept within that boundary, approaching and receding, but never transgressing the appointed Limit; and never deviating so far as to reduce unduly the Sectional-area (contrast these sketches with the Bedstead-leg of fig. 40; and the effect of a *broad* treatment, as compared with that of an unduly accentuated one, will be observed); in fig. 45 (the Anta-capital of the Propylæa, at Athens), in which the three Fillets are designed to oversail in such a manner that they are tangential to the curve of the under-surface of the "Hawk's-beak" Moulding, which curve (if produced) would be tangent to the lower Fascia, also; in 43 (the Architrave-cornice of the Pandroseion), in which the Mouldings are so designed that they coalesce into *groups*, as shewn by the black Line that is applied to the

cornice, and also in the adjacent thin Line; (this, one of the most beautiful cornices in the

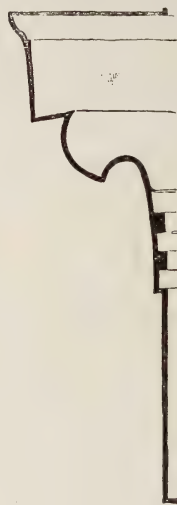


FIG. 45.

world, is a very compendium of Greek Art in subtle profiling); and in fig. 46 (the Entablature



FIG. 46.

of the Wellington Monument), in which the Mouldings are similarly designed *in groups*, shewn as before, and in which Alfred Stevens,

the Master, has shewn himself (as in other branches of the Art one and indivisible) not an unworthy disciple of the Greeks.

Mantle; and the Necklace (fig. 47) that marks the Modulation from the neck to the thorax—in ARCHITECTURE: in softening the hard



FIG 47.

The APPLICATION of this LAW is universal; and every Object or Set of objects, that has come under its governance, is thereby made more dignified and more worthy of the Art, Divine and Human, that renders the surroundings of our Life so beautiful.

DISREGARD of this Law may arise from two sources:—a Plenum and a Vacuum; the student may have *too-much* Detail which he desires to “work-in”—in which case, he needs judgment, *i.e.* Principles; or he may not have enough—in which case, he needs Observation, *i.e.* Study of the Works of both kinds of Art that surround him.

MOLLIFICATION is the third of the group of Laws which govern the design of Mass. The term is derived from two Latin words which signify the *rendering soft* of any Object. It is further extended from association of idea to include the rendering of Angles and Corners *round* or *blunt*; and the *breaking-up* of the Edges into a multiplicity of minute Shapes, which thus obviates the hard effect of a Straight-line. The L.H. sketches, **M**, in figs. 38 and 39, shew this extended meaning.

EXAMPLES are seen:—in NATURE: in every Fish that swiftly cleaves the water; and most other animals and plants—in DRESS: in the Lace-edgings that soften the hard line of the Collar or Sleeve against the Neck and Wrist; the Fringe that softens the hard Edge of the

Cornice-line along the flank of Greek Temples; also of the Arch-openings, by the Mahometans, as shewn in fig. 48 (two Arch-



FIG. 48.

openings from the Alhambra, in one of which, **r**, the cusplings are *radial*, and in the other, **v**, they are *vertical*—in FURNITURE, &c.: in the wooden chair (fig. 49), and the metal Candle-bracket (fig. 50), in which the Aim of the artists appears to have been: to soften or “mollify” all Straight-lines and

Corners into Curves : some of these softening are necessary under the Law of Functionality,

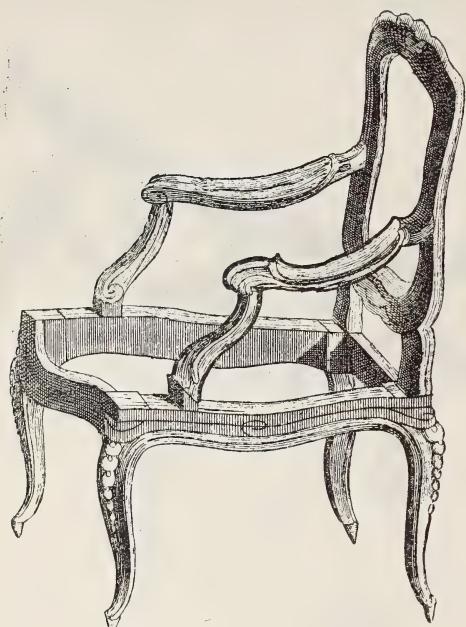


FIG. 49.

but others are designed in this manner for æsthetic-effect only, without any reason, and



FIG. 50.

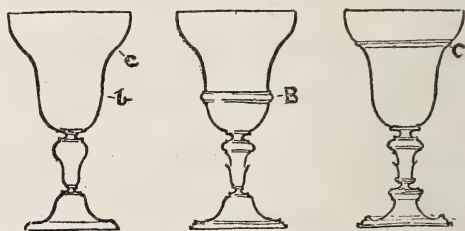
the observer will further perceive that the design of the Chair disregards the Law of Materiality, in a marked degree ; the Mirror-frame (fig. 51), in which the outer Edge is softened against the Wall ; the Italian Mirror-frames, of the XVI. century and onward, shew the desire for softening the edges, by the addition of Brackets underneath, Caryatids at the

sides, and pediment-shaped Crestings at the top—in PROFILING : in the L.H. sketch of



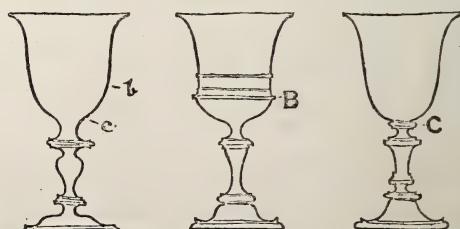
FIG. 51.

fig. 52, which shews too much Mollification,



THREE CURVES : INTERPOLATED MOULDINGS.

FIG. 52.



THREE CURVES : INTERPOLATED MOULDINGS.

FIG. 53.

each portion of the Cup being composed of three curves (convex, concave, and convex) joining at the points marked **b** and **c**, hence there is a want of Decision about the profile, which is corrected by the interpolation of the Moulding **B** (between the Pause and the Frieze) or **C** (between the Frieze and the Lip), and also in the Stem, and Base; the L.H. sketch of fig. 53, has similar faults (concave, convex, and concave, all coalescent) which are corrected by interpolated Mouldings, as before—in MOULDINGS: the student will observe that the sketches in fig. 54 are mouldings



MOULDINGS OF ONE CURVE.

FIG. 54.

of *one* Curve, those of fig. 55 are of *two* curves, joining at the points marked by a dot,



MOULDINGS OF TWO CURVES.

FIG. 55.

and those of fig. 56 are of *three* curves, similarly marked.



MOULDINGS OF THREE CURVES.

FIG. 56.

An ABUSE of Mollification is shewn in figs. 52, 53, and 56. The Single-curvature of mouldings is always strong and manly: the Double-curvature is refined and elegant: the Triple-curvature is always a sign of Decadence in any Style; leading to a want of Decision-of-Profile and of Clearness in Design; and it should be avoided except for mouldings round Openings (where the Profile is not seen) by every student until he has mastered the Art of Profiling, when, of course, he becomes a law unto himself.

DECISION is the fourth and last of the group of Laws which govern the design of Mass. The term is derived from two Latin words which signify the being *cut-off* (in a *determined* manner, without any softening of corners). The idea of *rectangularity* is now included in its application to Form; thus in fig. 38, the Square **D**, and in fig. 39, the Gable-end **D**, shew Decision. It is opposed to all Undulating shapes; and is antithetical to Mollification.

EXAMPLES are seen:—in NATURE: in the Craggy Rocks and other results of Geologic upheaval—in ARCHITECTURE: in the rectangular forms of the Dorian Order; and the mass-form of the Dentil-course shewn in the two sketches of figs. 43 and 46.

DISREGARD of this Law is seen in fig. 57 (the Cornice of the Temple of the Winds, at Athens, B.C. circa 80), and in fig. 58 (the Podium of the Monument to Philopappos, at Athens, A.D. 114), both built after the decline of Greek Art. Compare either with figs. 43, and 46.



FIG. 57.



FIG. 58.

The APPLICATION of these four Laws, each to its own proper parts in the Composition, requires much Experience and Skill; but the Result will be worthy of the thought bestowed on it.

UNITEDNESS is the Law, governing the

co-relation of different portions of the same Object, which prescribes that—(a) if these different parts are arranged *horizontally* with regard to each other, *i.e.* in rank: then some features, *e.g.* Mouldings, shall be carried-through all, for the purpose of (apparently) binding them together—and (b) if they are arranged *vertically*: *i.e.* in file: then some feature shall be carried-through across the horizontal divisions, for the same

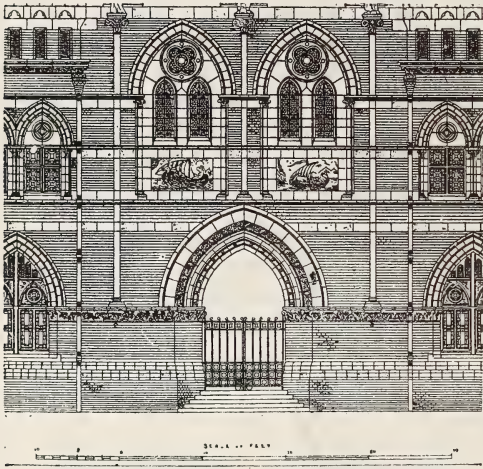


FIG. 59.

purpose — and further, that, though the separate parts might be each right in itself: yet each should appear incomplete by itself, and only attain perfection when in full combination and communion with all of its co-efficients. Without the influence of this Law, Objects appear like parts of different things placed fortuitously, in what may be termed “the Lob-worm” style of Design.

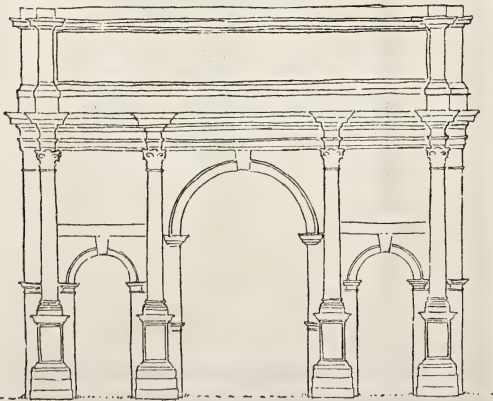


FIG. 60.

EXAMPLES are seen:—in NATURE: in all things, except such as are the result of Convul-

sion and its consequent Dislocation—in ARCHITECTURE: in the figs. 8, 9, 27, &c., in which the Cornices, String-courses and Plinths, bind (in appearance), the separate parts or bays, together; Prof. Aitchison, R.A., has pointed-out a similar effect, produced by the Arcade, which joins-together the two Western-towers, of Notre Dame, at Paris, in France; and by the over-lapping of the lower Colonnade in the Front of St. Paul's Cathedral, in London; the portion of the beautiful design, by the late Edward W. Godwin (fig. 59), also admirably exemplifies the influence of this Law.



FIG. 61.

DISREGARD of this Law is seen in the Arch of Septimius Severus at Rome (fig. 60), in which no single Moulding (below the Capitals)

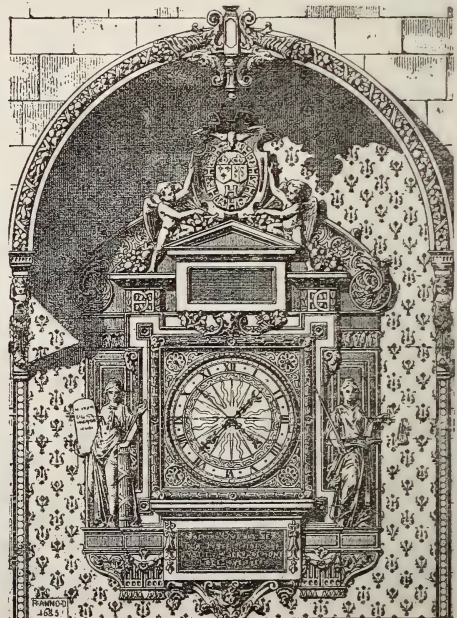


FIG. 62.

is carried-through; with the result that the lower portion appears to have belonged to *different* Buildings, which are here put-together. This disregard is obviated in fig. 61. Also, in fig. 62 (the Clock, on the Palais de Justice, at Paris) there is not a single Moulding that gives any feeling of Unitedness in the design; but the whole appears to be "made-up," of incongruous parts, somewhat after the



FIG. 63.

traditional Wardour Street Recipe. This disregard is obviated in fig. 63. Again, in fig. 64.



FIG. 64.

(the Church of S. Giorgio, at Venezia), only the Plinth is carried-through; and the Aisles

appear like an afterthought. This disregard is obviated in fig. 65 (which is not much like



FIG. 65.

a church; but neither is the other). And in fig. 66, is shewn a portion of the Palais de Justice, at Bruxelles. Here the absence of Unitedness is painfully apparent; there are no Binding-lines; and at the internal angle, where

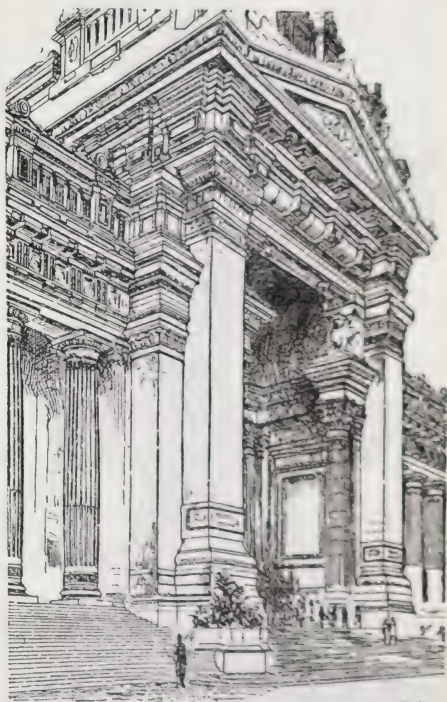


FIG. 66.

the Wing abuts against the Centre-portico, there is a hiatus like a Fault in Geological-strata. In fact, the huge structure, though

with much refined detail, and erected with all the experience of the last quarter of this century, is like a Mexican or Indian building in character, through this Disregard.

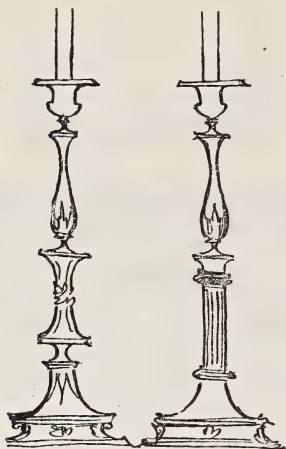


FIG. 67.

RETICENCE is one of the group of Laws that govern the Amount of Detail applied to

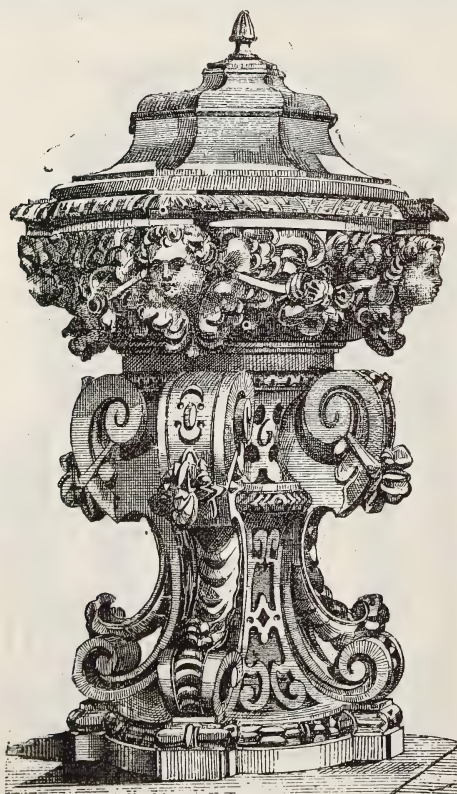


FIG. 68.

any Object. The term is derived from two Latin words which signify the *keeping silent*.

There is a "Chattering" in design, when the artist applies too much frivolous detail; and there is "Reticence" when he has learned to "hold his tongue", *i.e.* to introduce no detail that is not required. This, as in our Life, is one of the most difficult Laws to obey. The Spendthrift is generally foolishly considered to be a more amiable person than the Miser; and Profusion of detail (as analogous to Generosity) is more liked than dignified Reticence; but observant minds will assess each at its proper value.

The APPLICATION of this Law governs the amount of:—(a) Detail, (b) Curvature, &c. The amount of Detail will be treated of in RICHNESS, *q.v.*

EXAMPLES of Reticence in CURVATURE are seen:—in fig. 67, shewing two sketches for a Tall-Candlestick, of which the L.H. one is entirely composed of Curved-profiles, while the R.H. one shews a portion that is *vertical* without curvature, which it will be perceived, gives (by contrast) more value to the balauster-profile above it; so also in fig. 68, the Font is unpleasing by reason of the Turgidity of the masses; and fig. 69 shews an attempt to render it more "quiet," *i.e.* more Reticent.



FIG. 69.

FIGURES and ANIMALS are sometimes

added, to enrich the Profile, as shewn in figs. 70 and 71. When the Central-feature,



FIG. 70.

FIG. 71.

to which they are applied, is *clearly seen*, and they do not *supplant* it: then they are a pleasing addition, as in fig. 14, p. 902.

The Author regrets that the absence of Illustrations precludes the treating of the whole body of Principles and Laws in this subject. He has therefore termed this brief Essay, not “the” principles, but “some” principles; and he hopes to complete the whole at no long interval.

Miscellaneous.

ELECTRICAL MACHINERY IN PRUSSIA
IN 1898.

The following particulars are from a memorandum by the Commercial Attaché to H.M. Embassy at Berlin, printed in the *Board of Trade Journal*:—

“Every year the increase of electrical plant is becoming more marked in Prussia; and, though there are no complete statistics on the subject, a good idea of the advance that has been made is to be obtained from the *data* which exist as to electrical driving machinery, for this is chiefly driven by steam, and is, therefore, to be found in statistics. The latest returns for the beginning of 1898 are to be found in the following statement, which includes all State and private undertakings in Prussia, with the exception of those under the War Office and Admiralty. Of machines driving dynamos, there were in 1891, 983

with a horse-power of 49,489, whereas by 1898 this number had risen to 3,305 of 258,726 horse-power. In the former year there were 794 machines exclusively used for driving dynamos, while 180 were only partially used for this purpose. In the latter year there were 2,490 used exclusively for driving dynamos, while 815 were only partially used for this purpose.

“The increases here shown are enormous. It is worth noticing the great development since 1897. In that year the total horse-power was 191,913 only, whereas by 1898 it had risen to 258,726. During this interval of one year the number of machines had increased from 2,837 to 3,305.

“The particular kinds of electrical work to which these machines are made to supply the power, for 1898, are shown in the following table:—

USES TO WHICH ELECTRIC CURRENTS ARE PUT.		
Uses.	No. of Machines.	Horse-power.
1. For lighting purposes	2,873	154,772
2. For driving motors	61	10,785
3. For other purposes	25	7,278
4. For several purposes at the same time, and (a) For lighting and transmitting power	325	8,216
(b) For other purposes	21	1,675
Totals	3,305	258,726

“By far the greatest part of the electric power therefore is used for lighting purposes.

“The above statistics are taken from figures published, on the 30th of September, in the ‘*Reichsanzeiger*.’”

FIREWORKS IN CHINA.

During the year ended June 30, 1897, there were exported from China 26,705,733 lbs. of fire crackers, valued by the Chinese Imperial Customs at about £317,000. The entire export was from the province of Kwangtung. The shipments from the different ports were as follows:—Canton 1,067,200 lbs., Keeloon 24,074,267, Lappa 907,733, and Swatow 656,533 lbs. The exports represent only a small fraction of the amount manufactured and used in China. There are no large manufactories: the crackers are made in small houses and in the shops where they are sold. In the latter places the proprietors of the shop, his wife and children do the work. The use of crackers is universal in China, and has been as far back as history records. It is most probable that in the beginning they were used to frighten away evil spirits. Now they are most frequently an expression of good feeling or of ceremonious compliment. They are used at weddings,

births, and funerals; at festivals; religious, civil, and military ceremonies; at new year; to salute persons about to make a journey; and, in fact, on all occasions out of the ordinary routine. The United States Consul-General at Shanghai says that in making crackers, only the cheapest kind of straw paper which can be produced in the immediate locality where the crackers are made is used for the body of the cracker. A little finer paper is used for the wrapper. A piece of straw paper, 9 by 30 inches, will make 21 crackers $1\frac{1}{2}$ inches long and $\frac{1}{4}$ inch in diameter. The powder is also of the cheapest grade, and is made in the locality where used. It costs about 3d. per lb. For the fuse a paper (called "leather" in Shanghai) is used, which is imported from Japan, and is made from the inner lining of the bamboo. In other places a fine rice paper is used, generally stiffened slightly with buckwheat-flour paste, which the Chinese say adds to its inflammability. A strip of this paper, one-third of an inch wide by 14 inches (a Chinese foot) long is laid on a table, and a very little powder put down the middle of it with a hollow bamboo stick. A quick twist of the paper makes the fuse ready for use. The straw paper is first rolled by hand around an iron rod, which varies in size according to the size of cracker to be made. To complete the rolling a rude machine is used. This consists of two uprights supporting an axis from which is suspended, by two arms, a heavy piece of wood, slight convex on the lower side. There is just room between this swinging block and the top of the table to place the cracker. As each layer of paper is put on by hand, the cracker is placed on the table and the suspended weight is drawn over the roll, thus tightening it until no more can be passed under the weight. For the smallest "whip" crackers, the workman uses for compression, instead of this machine, a heavy piece of wood fitted with a handle like that of a carpenter's plane. In filling crackers, 200 to 300 are tightly tied together in a bunch; red clay is spread over the end of the bunch, and forced into the end of each cracker with a punch. While the clay is being treated a little water is sprayed on it, which makes it pack closer. The powder is poured in at the other end of the cracker. With the aid of an awl the edge of the paper is turned in at the upper end of the cracker, and the fuse is inserted through this. The long ends of the fuses are braided together in such a way that the crackers lie in two parallel rows. The braid is doubled on itself, and a large, quick-firing fuse inserted, and the whole is bound with a fine thread. The bundle is wrapped in paper and in this shape sent to the sea coast. A variety of cracker which is very popular in China is the "twice-sounding" cracker; it has two chambers, separated by a plug of clay, through which runs a connecting fuse. There is also a fuse extending from the powder in the lower chamber through the side of the cracker. When the cracker is to be fired, it is set on end, and fire applied to the fuse. The powder exploding in the chamber throws the cracker high in the air where the second charge is

exploded by fire from the fuse extending through the plug between the two chambers. In the manufacture of these the clay is first packed in with a punch to form the separating plug. The lower chamber is then loaded with powder and closed by turning over the paper at the end. The upper chamber is loaded and closed with clay. A hole is punched in the side of the lower chamber with an awl, and the fuse inserted through this opening.

General Notes.

RUSSIAN EGG TRADE.—The egg trade at Riga is said by H.M. Consul at that port to be assuming enormous proportions. In 1897, 29,842 tons were exported. This means that something like 430,000,000 eggs were shipped from this corner of Russia to Western Europe during the year, the bulk of them finding their way to the United Kingdom and Germany. It is probable that the trade will grow still larger on account of the increased facilities for conveyance.

MEETINGS FOR THE ENSUING WEEK.

- MONDAY, NOV. 7.**—Royal Institution, Albemarle-street, W., 5 p.m., General Monthly Meeting.
 Engineers, in the Theatre of the United Service Institution, Whitehall, S.W., 7 $\frac{1}{2}$ p.m. Mr. Perry F. Nursey, "The Preparation of Rhca Fibre for Textile Purposes."
 Sanitary Inst., 74A, Margaret-street, W., 8 p.m. Mr. A. S. Ackermann, "Principles of Calculating Areas, &c."
 London Institution, Finsbury-circus, E.C., 5 p.m. Very Rev. Dean Farrar, "Canterbury Cathedral."
 British Architects, 9, Conduit-street, W., 8 p.m. Opening Address by Prof. Aitchison, R.A., President.
- WEDNESDAY, NOV. 9.**—Sanitary Institute, 74A, Margaret-street, W., 8 p.m. Dr. J. Priestley, "Ventilation, Warming, and Lighting."
 Colonial Inst., Whitehall-rooms, Whitehall-place, S.W., 8 p.m. Hon. E. H. Wittenoom, "Western Australia in 1898."
 Civil Engineers, 25, Great George-street, S.W., 8 p.m. Prof. W. C. Roberts-Austen, "The Extraction of Nickel from its Ores by the Mond Process."
- THURSDAY, NOV. 10.**—London Institution, Finsbury-circus, E.C., 6 p.m. Sir J. Norman Lockyer, "The Recent Eclipse."
 Electrical Engineers, 25, Great George-street, S.W., 8 p.m. Prof. Silvanus Thompson, "Rotatory Convertors."
- FRIDAY, NOV. 11.**—Sanitary Institute, 74A, Margaret-street, W., 8 p.m. Prof. T. Roger Smith, "Sanitary Building Construction."
 Astronomical, Burlington-house, W., 8 p.m.
 Physical, Chemical Society's Rooms, Burlington-house, W., 5 p.m. 1. Discussion on Mr. A. Campbell's paper on "The Magnetic Fluxes in Meters and other Electrical Instruments," to be opened by Prof. W. E. Ayrton, F.R.S. 2. Prof. W. B. Morton, "The Propagation of Damped Electrical Oscillations along Parallel Wires." Mr. R. A. Lehfeldt, "The Properties of Liquid Mixtures."

Journal of the Society of Arts.

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FRIDAY, NOVEMBER 11, 1898.

All communications for the Society should be addressed to the Secretary, John-street, Adelphi, London, W.C.

Notices.**ARRANGEMENTS FOR THE SESSION.**

The First Meeting of the One Hundred and Forty-fifth Session will be held on Wednesday evening, the 16th of November, when an Address will be delivered by SIR JOHN WOLFE BARRY, K.C.B., M.Inst.C.E., F.R.S., Chairman of the Council.

Previous to Christmas there will be four Ordinary Meetings, in addition to the Opening Meeting. The following arrangements have been made :—

NOVEMBER 16.—Opening Address by SIR JOHN WOLFE BARRY, K.C.B., M.Inst.C.E., F.R.S., Chairman of the Council.

NOVEMBER 23.—“Long Distance Transmission of Electric Power.” By PROF. GEO. FORBES, F.R.S. SIR JOHN WOLFE BARRY, K.C.B., M.Inst.C.E., F.R.S., Chairman of the Council, will preside.

NOVEMBER 30.—“Photographic Developers and Development.” By C. H. BOTHAMLEY, F.C.S. COL. J. WATERHOUSE, Hon. Sec., Royal Photographic Society, will preside.

DECEMBER 7.—“Egypt and the Soudan, in 1897 and 1898.” By W. T. MAUD.

DECEMBER 14.—“Commercial Education.” By SIR ALBERT ROLLIT, LL.D., M.P.

Papers for meetings after Christmas :—

“Tuberculosis in Animals.” By W. HUNTING.

“Canals and Inland Navigation in the United Kingdom.” By L. F. VERNON-HARCOURT, M.A.

“Preservation of Timber.” By S. B. BOULTON.

“Electric Traction and its Application to Railway Work.” By PHILIP DAWSON.

“Coal Supplies.” By T. FORSTER BROWN.

“Wireless Telegraphy.” By W. H. PREECE, C.B., F.R.S.

“Leadless Glazes.” By WILTON P. RIX.

INDIAN SECTION.

The meetings of this Section will take place on the following Thursday afternoons, at 4.30 o'clock :—

January 19, February 9, March 9, April 13, May 11, 25.

FOREIGN AND COLONIAL SECTION.

The meetings of this Section will take place on the following Tuesday afternoons, at 4.30 o'clock :—

December 6, January 24, February 28, April 25.

At the meeting before Christmas the following paper will be read :—

TUESDAY, DECEMBER 6.—“The Yangtze Basin and the British Sphere.” By ARCHIBALD LITTLE, F.R.G.S., of Chungking. The Right Hon. SIR RICHARD TEMPLE, Bart., G.C.S.I., C.I.E., will preside.

*** Numerous lantern slides of the Upper Yangtze and beyond will be shown and described by Mrs. LITTLE.

APPLIED ART SECTION.

The meetings of this Section will take place on the following Tuesday evenings at 8 o'clock :—

January 31, February 21, March 14, April 18, May 2, 30.

CANTOR LECTURES.

The following courses of Cantor lectures will be delivered on Monday evenings, at 8 o'clock :—

PROF. VIVIAN B. LEWES, “Acetylene.” Four Lectures.

LECTURE I.—NOVEMBER 21.

The history of acetylene—Methods of formation—The chemistry of acetylene—The part played by acetylene in ordinary luminous flames.

LECTURE II.—NOVEMBER 28.

The commercial production of acetylene—Calcic carbide and its properties—The electric furnace and the various modifications in use for carbide manufacture—Carbide without electrical power—Carriage and storage of carbide.

LECTURE III.—DECEMBER 5.

The commercial generation of acetylene—The types of generator in use—The actions taking place in acetylene generators, and the effect upon the gas produced—The purification of acetylene for domestic consumption.

LECTURE IV.—DECEMBER 12.

The combustion of acetylene—Acetylene burners—Smoking and carbonising of burners—Burners for heating—Acetylene for gas engines—Diluted Acetylene and its applications.

DR. SAMUEL RIDEAL, “Bacterial Purification of Sewage.” Four Lectures.

January 16, 23, 30, February 6.

ARCHIBALD SHARP, A.M.Inst.C.E., “Cycle Construction and Design.” Four Lectures. February 20, 27, March 6, 13.

PROF. HENRY R. PROCTER, "Leather Manufacture." Four Lectures.

April 10, 17, 24, May 1.

JUVENILE LECTURES.

Two Lectures, suitable for a Juvenile audience, will be delivered on Wednesday evenings, the 4th and 11th of January, at Seven p.m.

EXHIBITION OF LITHOGRAPHS.

The Loan Exhibition of Lithographs which has been organised by the Department of Science and Art, at the suggestion of the Society of Arts, will be opened to the public on Monday, the 21st November, and will remain open until the 28th February next.

A large and widely representative collection of historical and artistic lithographs has been obtained, supplemented by a small set of examples of modern industrial lithography exhibited at the request of various firms who made application for space. Limits of space render it impossible to entertain any more offers of specimens for exhibition on this occasion.

The Exhibition has been arranged in a gallery adjoining the Machinery Section of the Southern Galleries, South Kensington Museum (Exhibition-road).

The Private view will be on Saturday, 19th inst. A ticket of admission, admitting bearer and friends, will be sent to any member of the Society who applies to the Secretary.

INDIAN SECTION COMMITTEE.

A meeting of the Committee of the Indian Section was held on Monday afternoon, 7th inst. Present: Sir Stuart Colvin Bayley, K.C.S.I., C.I.E. (Chairman), Lionel R. Ashburner, C.S.I., Sir M. M. Bhownaggee, K.C.I.E., M.P., Sir George Birdwood, K.C.I.E., C.S.I., LL.D., M.D., Major-Gen. Sir Owen Tudor Burne, G.C.I.E., K.C.S.I., F. C. Danvers, Sir Juland Danvers, K.C.S.I., Sir Charles A. Elliott, K.C.S.I., Sir John Jardine, K.C.I.E., Sir A. Mackenzie, K.C.S.I., Thomas H. Thornton, C.S.I., D.C.L., W. Martin Wood, with Sir Henry Trueman Wood, Secretary to the Society, and S. Digby, Secretary to the Committee.

The arrangements for the Session were considered.

Miscellaneous.

THE WINE PRODUCTION OF CALIFORNIA.

The California vintage of 1897, including the sweet wine production, has been the largest in the history of the industry, exceeding the previous record year of 1893 by over 7,000,000 gallons. With less acreage than existed some years ago the vines have been so prolific that the dry wine produced is far greater than usual and has been exceeded in only one or two seasons. The two countries of Sonoma and Santa Clara have surpassed all former yields and the quality of the wine promises to be among the best for many years. The acting British Consul-General at San Francisco says that producers and merchants are confronted with the problem of the disposition of the wine, and the cessation of the friendly relations which existed during 1895 and 1896 between these two classes adds gravity to the situation. The manager of the California Winemakers' Corporation estimates the vintage of dry wines as follows:—Sonoma county, 9,000,000 gallons; Santa Clara county, 7,750,000 gallons; Napa county, 4,500,000; miscellaneous, 4,500,000 gallons, making a total of 25,750,000 gallons. In considering the marketing of the crop the stock left over from former years will have to be taken into account, and this will probably amount to 11,000,000 gallons. The demand for the present year (1898) is placed by the manager at 23,000,000 gallons, calculated on a Pacific coast consumption of 8,000,000 and an export consumption of 15,000,000 gallons. Deducting these 23,000,000 from the 36,750,000 on hand, a surplus of 13,750,000 gallons will remain. Fermentation in 1897 is reported to have been perfect, and it is said to be the judgment of experts that the quality will be much superior to the average. The vintage of sweet wines is estimated at 6,500,000 gallons, and prices have been affected, to some extent, out of sympathy with the dry wine market. California port and sherry of good quality can be bought in car-load lots at from 1s. 6d. to 1s. 8d. per gallon. This wine is highly recommended by local medical men for invalids, and Consul-General Moore says it would probably command a ready sale in England if put on the market at a reasonable figure. The product of brandy is put down at 20,000,000 gallons. An experiment in handling red wine was tried last year at the Italian-Swiss Colony's vineyard situated at Asti, in the state of California. The grapes handled by the colony were far in excess of the cooperage facilities it possessed, and some means had to be devised to care for the surplus. Among the different plans suggested was that of building a concrete cistern, and this idea was finally adopted. An excavation was first made in a rocky hillside in the rear of the establishment. Next, walls of concrete, 2 feet in thickness, were put in, and the floor and top were added to in an equally substantial manner, the latter being supported by fifteen steel

girders. Then the entire surface was covered with a lining of pure cement, and, finally, this was glazed to the impermeability of glass. The whole cistern was buried beneath 3 feet of earth, the object of all these precautions being to preserve the wine at a uniform temperature. This cement tank is 104 feet long, 34 feet wide, and 24 feet high, and is capable of holding 500,000 gallons. The wine was kept in this reservoir for four months or more, and the experiment is said to have been entirely successful. It was then drawn off by gravitation into wooden tanks, in which it will be allowed to mature previous to being placed in barrels for shipment. There are said to be several advantages derived from treating the wine in this manner. One is that it can be maintained at a cool, even temperature; another is the equal blending of such a large quantity of wine at one time, and a third is the great saving in insurance which is expected to repay the cost of the construction of the tank in five years.

General Notes.

SLATE MARBLE IN BELGIUM.—According to a German report, Belgium exports a sort of black marble which is nothing else than prepared slate. The slate suitable for this purpose is first polished very smooth with a sandstone, so that no visible impression is made on it with the chisel; this is the rough polish. After this it is finely polished with artificial pumice stone and finally finished with extremely light natural pumice stone. The polished surface now presents a velvet-like soft appearance. The surface is then dried and heated thoroughly whereupon, the finely polished surface is impregnated with a heated mixture of oil and fine lamp black. This is allowed to remain for twelve hours. According to whether the slate used is more or less grey, the process is repeated until it loses its grey appearance. It is then polished thoroughly with emery which is taken on a linen rag, and finally polished with tin ashes to which is added some lamp black. After the polishing is finished was dissolved in turpentine is spread over it, and it is allowed to remain some time before it is rubbed off vigorously with a clean linen rag. The slate thus treated now has a deep black appearance, and looks like black marble, and the polish is just as durable as the latter. The polished surface can be etched, engraved, gilded and silvered, just the same as genuine marble.

MEETINGS FOR THE ENSUING WEEK.

MONDAY, NOV. 11. Scottish Society of Arts, 117, George-street, Edinburgh, 8 p.m. Inaugural Address by the President.

Imperial Institute, South Kensington, 8½ p.m. Mr. Henry Caracciolo, "Trinidad, including some Account of the Recent Hurricane in the West Indies."

Geographical, University of London, Burlington-gardens, W., 8½ p.m.

Sanitary Institute, 71A, Margaret-street, W., 8 p.m.

Dr. G. Reid, "Sanitary Appliances."

London Institution, Finsbury-circus, E.C., 8 p.m.

Prof. Sidney J. H. Lee, "Secondary Education."

TUESDAY, NOV. 15. Civil Engineers, 25, Great George-street, S.W., 8 p.m. Mr. William Beech, F.R.S.

"Electrical Transmission of Power in Mining."

Statistical, in the Theatre of the United Society of Arts, Whitehall, S.W., 8 p.m. Sir Henry

C. Burdett, "Old Age Pensions."

Photographic, 12, Hanover-square, W., 8 p.m.

(Photo-mechanical Meeting.) 1. Mr. S. A. E.

Tallent, "Rapid Dry Plates for Process Work."

Combined Screen and Colour Negative in the Theatre of the United Society of Arts, Whitehall, S.W., 8 p.m.

1. Mr. R. (Ald) Bayly, "The Melting and Setting Points of Gelatine Emulsions, and their modification."

Zoological, 3, Hanover-square, W., 8½ p.m. 1. Mr.

George Hampson, "A Revision of the Mammals of the Subfamily Pyraustinae and Family Pyraustinae."

Part I." 2. Mr. W. E. d. Winton, "List of Mammals obtained by Mr. R. McD. Hawker during a recent Expedition to Somaliland."

3. Mr. Oldfield Thomas, "Mammals collected by Mr. J. D. La Touche at Kuantun, N.W. F.K.M."

WEDNESDAY, NOV. 16. SOCIETY OF ARTS, John-street, Adelphi, W.C., 8 p.m. Opening meeting of the 115th Session by Sir John Wolfe Barry, Chairman of the Council.

Meteorological, 25, Great George-street, S.W., 7½ p.m. 1. Wind Force Committee, "Report on Experiments upon the Exposure of Anemometers at different elevations."

2. Captain D. Wilson-Barker, "Comparison of Estimated Wind Force with that given by Anemometers."

3. Mr. William Marriott, "The Tornado at Cambridge, October 29th, 1898."

Sanitary Institute, 71A, Margaret-street, W., 8 p.m.

Mr. J. Wright Clark, "Details of Plumbing Work."

Microscopical, 25, Hanover-square, W., 8 p.m. An Exhibition of Thum's Slides of Diatoms, mounted in high reflective media.

Mining and Metallurgy, Geological Museum, Jermyn-street, S.W., 8 p.m. 1. Mr. John McGonnigle, "Notes on Dry and Wet Crushing with Cyanide Treatment, in New Zealand."

2. Mr. Frank Merriks, "Remarks on Dry and Wet Crushing."

3. Mr. Alfred James, "Notes on a Process for Treating Slimes without Filtration or Decantation."

THURSDAY, NOV. 17. Linnean, Burlington-house, 8 p.m.

1. Mr. F. O. Pickard Cambridge, "Some Spiders from Chili and Peru."

2. Mr. Spencer Moore, "Botanical Results of Journey into the Interior of Western Australia."

Chemical, Burlington-house, W., 8 p.m. 1. Dr.

E. Divers and T. Higa, "Preparation of Hyponitrate from Nitrite through Oxyamidodisulphonate."

2. Dr. E. Divers (a) "Absorption of Nitric Oxide in Gas Analysis;" (b) "Interaction of Nitric Oxide with Silver Nitrate;" (c) "Preparation of Pure Alkali Nitrites;" (d) "The Reduction of an Alkali Nitrite by an Alkali Metal;" (e) "Hyponitrites: their preparation by Sodium or Potassium and Properties."

London Institution, Finsbury-circus, E.C., 6 p.m.

Dr. H. R. Hill, "The Story of the Antarctic."

FRIDAY, NOV. 18. Civil Engineers, 25, Great George-street, S.W., 8 p.m. (Students' Meeting.) Mr. Cecil Lightfoot, "Liquid Air: a short description of its Production, and summary of its Application to the Chemical or other Industries."

Sanitary Inst., 71A, Margaret-street, W., 8 p.m.

Mr. W. C. Tyndale, "House Drainage."

CONTRIBUTIONS TO THE READING-ROOM.

The Council beg leave to acknowledge, with thanks to the Proprietors, the receipt of the following Transactions of Societies and Periodicals.

TRANSACTIONS, &C.

American Chemical Society, Journal.

American Institute of Electrical Engineers, Transactions.

American Philosophical Society, Proceedings and Transactions.

American Society of Civil Engineers, Transactions and Proceedings.

Architectural Association, Notes.

Association of Engineering Societies, Journal.

Australasian Association for the Advancement of Science, Report.

Bath and West and Southern Counties Society, Journal.

British Association for the Advancement of Science, Report.

British Guiana, Royal Agricultural and Commercial Society, Journal.

British Horological Institute, Horological Journal.

Camera Club, Journal.

Canada, Royal Society, Proceedings and Transactions.

Canadian Institute, Transactions.

Canadian Society of Civil Engineers, Transactions.

Chemical Society, Journal.

Cleveland Institution of Engineers, Proceedings.

Cymmrodorion, Honourable Society of, Transactions.

East India Association, Journal.

Farmers' Club, Journal.

Franklin Institute, Journal.

Geneva, Société des Arts, Bulletin de la Classe d'Industrie et de Commerce.

Geological Society, Quarterly Journal.

Imperial Institute, Journal.

Incorporated Gas Institute, Transactions.

India, Geological Survey of, Memoirs, Records and Palæontology Indica.

—, Government of, Agricultural Ledger.

Indian Meteorological Department, Report.

Institute of Bankers, Journal.

Institution of Civil Engineers, Minutes of Proceedings.

Institution of Electrical Engineers, Journal.

Institution of Engineers and Shipbuilders in Scotland, Transactions.

Institution of Junior Engineers, Record of Transactions.

Institution of Mechanical Engineers, Proceedings.

Institution of Mining and Metallurgy, Transactions.

Institution of Naval Architects, Transactions.

Iron and Steel Institute, Journal.

Jamaica, Institute of, Journal.

Japan, College of Science, Imperial University, Journal.

Japan Society, Transactions and Proceedings.

Kew Gardens Bulletin.

Linnæan Society, Journal.

London Association of Foremen Engineers and Draughtsmen, Publications.

London Chamber of Commerce, Journal.

Lyon, Société d'Agriculture, Sciences et Industrie, Annales.

Manchester Literary and Philosophical Society, Memoirs and Proceedings.

Massachusetts Institute of Technology. Technology Quarterly and Proceedings of the Society of Arts.

Munich, Polytechnischer Verein, Bayerisches Industrie-und-Gewerbeblatt.

National Association for the Promotion of Technical and Secondary Education. Record.

National Indian Association, "The Indian Magazine and Review."

Nederlandsche Maatschappij ter Bevordering van Nijverheid, Wekelijkoche Courant de Nijverheid.

New South Wales, Royal Society, Journal and Proceedings.

North-East Coast Institution of Engineers and Shipbuilders, Transactions.

Nova Scotian Institute of Science, Transactions.

Paris, Conservatoire National des Arts et Metiers, Annales.

—, Société d'Encouragement pour l'Industrie Nationale, Bulletin.

—, Société de Géographie Commerciale, Bulletin.

—, Société Internationale des Electriciens, Bulletin.

—, Société Nationale d'Acclimatation de France, Revue.

Patent Agents, Chartered Institute of, Transactions.

Patent-office, Illustrated Official Journal.

Pennsylvania (Western), Engineers' Society of, Proceedings.

Pharmaceutical Society, "The Pharmaceutical Journal."

Philadelphia, Academy of Natural Sciences, Proceedings.

—, Engineers' Club Proceedings.

Quekett Microscopical Club, Journal.
 Royal Agricultural Society, Journal.
 Royal Colonial Institute, Proceedings.
 Royal Cornwall Polytechnic Society, Annual Report.
 Royal Geographical Society, "The Geographical Journal."
 Royal Institute of British Architects, Journal.
 Royal Institution of Great Britain, Proceedings.
 Royal Irish Academy, Transactions and Proceedings.
 Royal Meteorological Society, Quarterly Journal.
 Royal National Life Boat Institution, "The Life Boat."
 Royal Photographic Society of Great Britain, "The Photographic Journal."
 Royal Scottish Society of Arts, Transactions.
 Royal Society, Philosophical Transactions and Proceedings.
 Royal Society of Edinburgh, Transactions and Proceedings.
 Royal Statistical Society, Journal.
 Royal United Service Institution, Journal.
 Sanitary Institute, Journal.
 Society of Antiquaries, Archæologia and Proceedings.
 Society of Biblical Archæology, Proceedings.
 Society of Chemical Industry, Journal.
 Society of Dyers and Colourists, Journal.
 Society of Engineers, Transactions.
 Society of Public Analyst, "The Analyst."
 South Wales Institute of Engineers, Proceedings.
 Victoria Institute, Journal of the Transactions.

PERIODICALS.

Weekly.

Amateur Photographer.
 American Architect and Building News.
 American Gas Light Journal.
 American Manufacturer and Iron World.
 Architect.
 Architecture and Building (New York).
 Athenæum.
 Bradstreet's.
 British Architect.
 British Journal of Photography.
 Builder.
 Building News.
 Capitalist.
 Chemical News.
 Chemist and Druggist.
 Chronique Industrielle.
 Colliery Guardian.
 Colonies and India.
 Commerce.
 Cosmos: Revue des Sciences.
 Eclairage Electrique.
 Electrical Engineer.
 Electrical Review.
 Electrician.
 Electricien.
 Electricity.
 Engineer.

Engineering.
 Engineering Record (New York).
 English Mechanic.
 Gardeners' Chronicle.
 Gardening World.
 Herapath's Railway Journal.
 Indian and Eastern Engineer.
 Industries and Iron.
 Invention.
 Iron and Coal Trades Review.
 Ironmonger.
 Journal of Gas Lighting.
 Journal d'Hygiène.
 Land and Water.
 Mechanical Engineer.
 Medical Press and Circular.
 Miller.
 Millers' Gazette.
 Mining Journal.
 Moniteur Industriel.
 Musical Standard.
 Nature.
 Photographic News.
 Photography.
 Practical Engineer.
 Produce Markets' Review.
 Public Health Engineer.
 Publishers' Circular.
 Queen.
 Revue Industrielle.
 Sanitary Record.
 School Board Chronicle.
 Schoolmaster.
 Scientific American.
 Shipping World.
 Surveyor.
 Textile Mercury.
 Warehouseman and Draper.

Fortnightly.

Brewers' Guardian.
 Corps Gras Industriels.
 Finance Chronicle.
 Irish Builder.
 Jeweller and Metalworker.
 Moniteur des Produits Chimiques.
 Perak Government Gazette.

Monthly.

Arms and Explosives.
 Bookseller.
 Brewers' Journal.
 British Indian Commerce.
 British Trade Journal.
 Building Societies' Gazette.
 Cabinet Maker and Art Furnisher.
 Canadian Patent Office Record.
 Caterer and Refreshment Contractors' Gazette.
 Dyer and Calico Printer.
 Educational Times.
 Engineering Magazine (New York).

Furniture and Decoration.
 Giornale del Genio Civile.
 Hardware Trade Journal.
 Inland Architect (Chicago).
 Irish Textile Journal.
 Knowledge.
 Leather Trades' Circular.
 Machinery.
 Machinery Market.
 Marine Engineer.
 Mariner.
 Metallographist.
 Moniteur Scientifique.
 Music.
 Musical Times.
 Nautical Magazine.
 Oesterreichische Monatsschrift für den Orient.
 Oils, Colours, and Drysalteries.
 Painting and Decorating.
 Paper Makers' Monthly Trade Journal.
 Piano, Organ, and Music Trades Journal.
 Plumber and Decorator.
 Pottery Gazette.
 Propriété Industrielle.
 Railway Engineer.
 Saddlers, Harness Makers, and Carriage Builders' Gazette.
 St. Louis and Canadian Photographer.

Science Abstracts.
 Sugar Cane.
 Symons's Monthly Meteorological Magazine.
 Textile Manufacturer.
 Trade and Industry.
 Textile Recorder.
 Ulster Agriculturist.
 Watchmaker, Jeweller, and Silversmith.

Two-Monthly.

Coach Builders', Harness Makers', and Saddlers' Art Journal.

NEWSPAPERS.

Bombay Gazette (Overland Summary).
 Ceylon Observer (Overland Edition).
 Daily Inter Ocean (Chicago).
 Home and Colonial Mail.
 Home News.
 London Commercial Record.
 London and China Telegraph.
 Newcastle Weekly Chronicle.
 Nottinghamshire Guardian.
 Shipping Gazette and Lloyd's List (Weekly Summary).
 Times of Ceylon (Weekly Summary).
 Times of India (Overland Weekly Edition).
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